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The Peel Board of Education

Science Review

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PGSCIENC/4436

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1. INTRODUCTION

Science education has been the focus of many new Ministry initiatives since 1984. Renewed interest in science education has resulted in policy statements for Primary/Junior, (1988) and Intermediate/Senior Divisions (1987). This has compelled Boards of education to ensure the translation of Ministry policy statements and curriculum guidelines into usable programs at the school level.

As well, the Science Council of Canada conducted a four-year study (Background Study 52, 1984) to provide a historical perspective for science education in Canadian schools and to propose recommendations for future directions. The final report (Report 36, 1984) outlined current and future initiatives in science education to allow students to leave school prepared to participate as informed citizens in a technological society.

In anticipation of new Ministry directives, and extensive new policy documents, the Peel Board of Education designed and conducted an extensive K-OAC science study to determine the current state of science education in Peel schools (1986-88). The findings of this science review have yielded valuable insights into program, teacher and students needs, and thereby can provide direction to assist in effective implementation and delivery of science programs in Peel.

The Peel Board of Education Science Review is subdivided into four main sections based on tabulated data:

- Student Survey;
- Teacher Survey;
- Principal, Superintendent, and Resource Teacher Interviews/Surveys;
- Review of Science Examinations and Written Curricula.

The executive summary for each of the four sections are found at the beginning of the survey reports and are colour coded to easily locate the corresponding results. The questionnaires used for each of the sections are available upon request.

2. General Observations

The overall purpose of this science review was to provide detailed insight into the current state of science education in The Peel Board of Education. Investigated in this science review were a variety of issues that could affect the delivery of an effective science program:

- teacher qualifications and experience;
- inservice programs;
- leadership;
- curriculum, instruction, and evaluation;
- facilities and resources;
- gender differences;
- special education.

Teacher Qualifications and Experience

Overall the teacher survey profiles science teachers in Peel as reasonably well qualified, experienced and highly motivated. The majority of science teachers at all levels possess a university degree and a minimum of 10 years teaching experience. Although the majority of teachers suggest they would not avoid teaching science given the opportunity, formal educational preparation in science is lacking in those teaching at the early and middle levels. Three quarters of all early and one half of all middle level teachers have taken neither a university mathematics nor science course. Therefore science teachers at these levels tend not to be specialists in science. The situation is very different at the secondary level where 81% of teachers have taken university level mathematics and science courses.

Interviews with administrators reveal that elementary principals believe the lack of science background has no impact at the early level and a negative impact at the middle level. Superintendents believe unanimously that teacher background and experience are an obstacle to the achievement of science objectives in the classroom. The survey conducted with resource teachers indicate that they concur with superintendents on this issue. Not only do resource teachers believe the lack of science background has a negative impact at the primary, junior, and middle levels but they also report discomfort among the teachers of science, especially at the junior level.

Linked to the qualification factor is the length of teaching experience. The teacher survey shows that most teachers have at least fourteen years of teaching experience with the average age of science teachers to be between 36 and 45 years of age. Similar to the Science Council of Canada study (Report 36, 1984), it is believed that although this can have positive benefits for a student's science education, it may pose problems in bringing about change from traditional methods of teaching.

The length of experience in teaching science appears to vary from level to level. At the early level 61% of teachers have been teaching science for more than 10 years, compared to 42% at the middle level and 66% at the secondary level. This implies a higher degree of teacher turnover at the middle level which may not permit teachers to build a comfort level in the area of science.

Length of teaching experience becomes especially important in light of new Ministry policy statements in science at all levels (1988). In the Primary and Junior Divisions the Ministry is mandating an integrated approach with emphasis on relevance and a strong active learning component. At the secondary level the policy statement requires teachers to rethink the way they have been teaching science in order to emphasize scientific literacy, relevance, and societal implications and applications. Science teachers will therefore continue to require support and direction in developing and implementing new science programs.

Inservice Programs

The majority of teachers rank the inservice programs in science as either non-existent or ineffective. Over one half of the early level principals (57%) and the majority of resource teachers report the occurrence of less inservice in science relative to other subject disciplines. Both groups believe that more inservice in science is required.

Teachers indicate a willingness to participate in science inservice programs. The granting of release time is preferred by them to inservice offered outside of school hours. With respect to the type of inservice offered, teachers at all levels prefer informal meetings with, and workshops given by, other science teachers. Approximately one half of early and middle level science teachers value workshops given by resource staff.

Given a list of various inservice formats at least one half of early level science teachers report experiencing no informal meetings with other science teachers, consultation with a principal or vice principal, consultation with the coordinator or consultant, visits to other teachers' classrooms, and conferences or meetings by science teachers or organizations. Early level teachers (43%) also report little experience with inservice involving workshops given by other teachers and resource teachers. At the middle level just over one half of science teachers report no experience with visits to other schools, classrooms and science conferences. About one-half of all science teachers actively seek the help they need to improve their programs.

Leadership

Science teachers, in the teacher survey, were asked to indicate the type of leadership in place for science at the school level. The majority of early level teachers (74%) indicate that there is no particular leadership in place for science at the school level. At the middle level 59% of teachers indicate that a group of teachers at the school provide leadership in science while 41% report no particular form of leadership. The findings based on interviews with principals and superintendents indicate little concensus among issues related to science.

Curriculum, Instruction and Evaluation

Various aspects of science programs were investigated in each of the four sections of the science review. The review of written curricula reveal that documents developed at the Board level adhere closely to Ministry policy statements. Findings in the teacher survey indicate that teachers at all levels do not use Ministry guidelines for the purpose of instructional planning, but rely on Peel documents.

At the early level very little formal planning is done for science. Long range plans at the early level, that were found, often proved to be inconsistent with Ministry and Board level documents. This is surprising in light of the fact that early level teachers report heavy reliance on Board documents for instructional planning. The number of long range plans are greater and of a higher calibre at the middle level. Although planning at the secondary level is more complete and sophisticated, their courses of study obviously do not yet fully reflect the recent changes in Ministry guidelines. The implementation of the new guideline courses in the schools, intermediate and senior, is to be completed by 1991. Implementation of the new policy statement for Primary and Junior Division science is to begin September 1989.

The teacher survey, resource teacher survey and administrator interviews all made reference to the 14 science council objectives. Early level teachers ranked 3 of the 14 objectives as very important: social skills; attitudes appropriate to scientific endeavour; and investigative skills and processes. Early level teachers indicate a comfort level with achieving the top ranked objectives, however there are three objectives in which teachers perceive themselves as less effective: understanding the relevance of science to the needs and interests of men and women; understanding the way scientific knowledge is developed; and understanding the role and significance of science in modern society. These objectives, along with the remaining ones ranked as less important, are inextricably linked to the new policy statements recently released by the Ministry.

At the middle level the teachers rank 10 of the 14 objectives as very important. This increase in the number of objectives perceived as important reflects the Ministry's expectation that a wider range of areas be addressed at this level. Middle level teachers report a comfort level with most of the objectives ranked as important. Middle level teachers are least comfortable with addressing the following three objectives: understanding the relevance of science to the needs and interests of men and women; understanding the way scientific knowledge is developed; and understanding the role and significance of science in modern society. These are the same three objectives with which early level teachers are uncomfortable.

Teachers at the secondary level rank 8 of the 14 objectives as important. The 8 objectives ranked important do reflect a slight shift in thinking away from content. However, teachers perceive themselves as most effective in the area of content. Similar to the early and middle level teachers, secondary teachers are less comfortable with achieving the objective "understanding the relevance of science to both men and women."

Examining student perceptions of the importance of science can give an indication as to the effectiveness of teachers with respect to certain objectives. Most students at each grade level surveyed indicate that science is important to them personally and to the country as a whole. However, on most items in the Importance of Science subscale, males respond more positively than females. This refers back to the objective teachers were least comfortable with achieving in the science classroom, "understanding the relevance of science to the needs of both men and women."

The objective "relating science to career opportunities" was one that teachers ranked lower both in terms of importance and degree of effectiveness. In the student survey the majority of students in grade 9 (60%) and senior science (68%) classes agree that knowledge of science is an important requirement for future jobs. More male than female students in Grade 9 express positive attitudes toward careers in science. At the grade 9 (41%) and senior level (54%) students report that teachers talk "often" or "sometimes" about possible careers in science. Only 3% of students in grade 9 and 4% of senior level students want to become science teachers.

Teachers were asked to indicate obstacles that would affect the achievement of science objectives in the classroom. Teachers at all levels rank institutional arrangements (timetable, class size) as a major obstacle to. Early level teachers indicate that facilities, equipment and curriculum resources are also obstacles at the classroom level.

The teacher survey indicates limited instructional strategies and methods of evaluation used by teachers. The lack of student involvement in decision making with respect to topics or problems being examined in science class is evident in both the teacher and student surveys. Teachers report most frequent effective use of teacher directed instruction and small group investigation. The student survey substantiates what the teachers report to be occuring in the science classroom. The most frequent activity that students report at all grade levels is the copying of notes from the blackboard. At the grade 9 and senior level the majority of students report that they "never" do field work.

The amount of instructional time for science at the early and middle levels appears to vary between schools. Overall the amount of time spent on science is less than that prescribed by the Peel Board of Educations' Program requirements. The perception of the amount of time given or needed to accomplish objectives in science vary among all groups surveyed; teachers, principals, superintendents, and resource teachers.

Similar to the area of classroom instruction, students are not involved in establishing criteria for evaluation. As the students move through the various grades there is a greater and greater emphasis on summative evaluation techniques and almost a complete absence of formative evaluation.

Facilities and Curriculum Resources

Early level teachers report that the physical facilities available for science are "poor" or "very poor". This corresponds to the finding that the majority of early teachers find physical facilities and equipment the major obstacle to achieving science objectives in the classroom. Physical facilities and equipment at the secondary level are examined on an annual basis and upgrading of facilities and capital replacement are items included in regional budget allocations.

Early and middle level teachers report a reliance on board developed curriculum materials for instructional purposes. Early level teachers appear less satisfied with curriculum resources than middle level teachers. Early level teachers (81%) report that curriculum resources are a major obstacle to the achievement of science objectives in the classroom compared to 66% of teachers at the middle level.

Gender Difference

Gender difference is another factor seen in each of the four sections of the science review. The demographic findings of the teacher survey indicate a male to female ratio which changes from a 1:3 ratio at the early level to a 2:1 ratio at the middle level to a 3:1 ratio at the secondary level. Disparity exists for the length of teaching experience betwen male and female science teachers at the secondary level. One half of female secondary science teachers have less than 10 years teaching experience, compared to 15% of males in the same category. Related to this is the fact that female science teachers at the secondary level are more likely to teach in more than one subject area. The survey also indicates that female science teachers are more likely to teach intermediate courses at the general and basic level.

Teachers and principals perceive no gender difference related to achievement, motivation, or ability. Superintendents believe that male students are more motivated than female students but report no gender difference related to achievement or ability. Resource teachers perceive differences related to the enjoyment of science only at the middle level where males appear to enjoy science more.

In the student survey gender differences are evident as early as grade 5. More male than female grade 5 students express a preference for mathematics and science. More female students at the grade 5 level express positive attitudes toward school while more male students give positive responses about the importance of science. The exact same trend is seen in the grade 9 and senior level surveys.

Another interesting gender difference is that more female than male students at the grade 9 level report that the teacher "never" uses their ideas or suggestions and that they "never" make up their own laboratory problems and then solve them with the help of the teacher. At the senior level biology is more popular with female students, while chemistry and physics are more favoured by male students.

Special Education

Teachers at all levels report having exceptional students in their classroom. However, only 38% of science teachers at the early and 28% at both the middle and secondary levels possess special education qualifications.

Over one half of science teachers at all levels report minimal or no liaison with the special education teacher(s) in the school. Science teachers do report the use of a variety of modifications to both classroom instruction and methods of evaluation for exceptional students.

3. Summary

The February 19, 1988 professional development conference entitled Focus: Science Education in Peel highlighted the findings of this Peel Board of Education Science Review. The high degree of interest generated by the science review is reflected by the numerous groups of educators who met subsequent to the Focus conference to develop recommendations for an action plan. These groups consisted of primary, junior, intermediate and senior teachers, resource teachers, science department heads, assistant heads of science departments, elementary and secondary principals, and program department staff. These groups have identified a number of areas which should be addressed based on the specific findings of this Peel Board of Education Science Review.

The groups concluded that reviews of science programs should be continued to ensure the presence of the Ministry goals of education and of the Ministry aims in science curricula for all divisions. This should improve the consistency of science programs throughout the Peel region. In addition, program resources in elementary schools, (consumable items, capital items, physical facilities), should be reviewed for adequacy and congruence with Ministry and Board level curricular documents in science. This review process should lead to a plan for a systematic, school based staff development program which should be provided for teachers and administrators to support the effective implementation of science programs, JK through OAC.

As well, these work-groups have noted that while the findings depict a state of science teaching which is considerably less than satisfactory for Peel, the review does indicate that Peel's situation is considerably better in many instances than the national realities. There are many outstanding programs in Peel schools which can serve as models for improvement across the school system. In the past two years, there has been a significant increase in resource teacher involvement in science work, facilities have been renovated, and the review itself did much to stimulate administrator interest and commitment to science.

Through the release of science documents in 1988 for all levels, JK through OAC, the Ontario Ministry of Education has signalled the time for science renewal. The program department in Peel has taken proactive steps to begin to meet this challenge through: the completion of an extensive science review, JK through OAC; the on-going development and review of exemplary courses of study at the intermediate and secondary levels; the organization of a planning and implementation team for primary and junior division science; the acquisition of an innovative inservice grant in science totalling $19,000.00 through the Ministry; and conferences such as Focus: Science Education in Peel. These initiatives mark the beginning of science renewal in the Peel region. The results contained in the Peel Board of Education Science Review will provide the necessary direction to assist in effective review, development and implementation of science programs in Peel.

A detailed action plan for the renewal of science in Peel will be provided to the Board, later this fall.

4. EXECUTIVE SUMMARIES

EXECUTIVE SUMMARY - Student Survey

This study surveyed the attitudes and opinions of grade 5, grade 9, and senior division students about science in school. Three samples were included in the study: 1,084 students in grade 5; 1,353 students in grade 9; and 1,268 students in the senior division.

The instruments used to survey the students were borrowed from the Second International Science Study. Each instrument contained three sections. The first of these sections related to marks in mathematics and science, preference for mathematics and the sciences, use of calculators and computers, future educational plans, science courses taken, and pattern of doing homework. The second section of each instrument contained attitude statements about school and science, and the third section consisted of items related to activities which take place during science learning.

The major findings of the study are summarized below:

1. Most students like mathematics and science as much as other school subjects.
2. Most students feel that their marks in mathematics and science are average, compared to marks in other school subjects.
3. Most students have calculators for use at home and at school. Although most students have access to computers at school, few of them report having used the computer.
4. Most students in grade 9 and in the senior division intend to acquire education beyond high school.
5. Most students in grade 9 and in the senior division spend time each week on general homework and homework in science.
6. Grade 5 children do not use a science textbook, although sometimes they refer to library books in learning science. Most grade 9 and senior division students use a textbook and seldom consult other books in learning science.

7. Students rarely have an opportunity to choose their own topics in science or to make suggestions in planning science lessons.

8. Students do laboratory work as part of their science classes, often or sometimes in small groups, guided by the teacher or written instructions.

9. Most science learning takes place indoors and consists of instruction and laboratory work. Students are often tested on what they have learned in science.

10. Almost all students report that school is generally challenging and interesting and that they have a desire to get as much education as possible. However, most of them also indicate that they don't enjoy everything about school, including spending time at school.

11. Most students agree that science is important to the betterment of mankind, and they consider the subject an enjoyable and interesting one. Among senior division students, biology is popular with girls, while physics and chemistry are favorites with boys.

12. Most grade 9 and senior division students do not want to become science teachers but would consider other careers in science. The majority of the students do not feel that science is important for getting a good job.

EXECUTIVE SUMMARY - Teacher Survey

The purpose of the Teacher Survey portion of The Peel Board of Education Science Review was to assess the demographics, educational background, attitudes, perceptions, and current practices of science teachers in kindergarten-through-secondary school science classes. Questionnaires distributed to teachers from the elementary panel included 296 primary generalists, 283 junior generalists, 87 grade 7 and 8 science teachers, and 32 teachers of contained gifted classes. In total 363 elementary teacher questionnaires were returned for analysis. All 284 secondary school teachers timetabled to teach one or more classes of natural science were included in the secondary sample. In total 202 secondary teacher questionnaires were returned for analyses.

The two instruments used in the survey - one for elementary and one for secondary teachers - were adapted from the Science Council of Canada Background Study 52. Each instrument contained five sections which included questions on general information; teaching responsibilities and institutional arrangements; inservice, curriculum and instruction; and student abilities and interests.

The major findings of the study are summarized below:

1. Science teachers at the elementary level (K-6) are primarily female, in the 36-45 age range, with more than 14 years teaching experience. Science teachers above the elementary level are primarily male, in the 36-45 age range, with a minimum of 10 years teaching experience.

2. A 1:3 male-female science teacher ratio exists at the early level (K-6); a 2:1 male to female ratio exists at the middle level (7-8); and at the secondary level (9-13), a 3:1 male to female ratio prevails.

3. The least experienced science teachers are males at the early level and females at the middle and secondary levels.

4. Most science teachers possess a university degree. New teachers entering into the profession are more highly qualified than teachers with 10+ years of experience.

5. Three quarters of all early level and one half of all middle level science teachers have taken neither a university level mathematics or science course. Females are more likely than males to be lacking these university level courses.

6. Few teachers at the early and middle levels are specialists in science.

7. At the secondary level, females are more likely than males to be teaching in more than one subject area.

8. The majority of science teachers at all levels are lacking special education qualifications.

9. Four out of every five science teachers say they would not avoid teaching science given the opportunity.

10. There is more satisfaction with teaching science among male teachers especially at the middle level.

11. Early level teachers report that 3 of the 14 science objectives are very important: social skills, attitudes appropriate to scientific endeavour; and investigative skills and process. These are also the objectives early teachers believe they are the most effective in achieving.

12. Middle level teachers rank 10 of the 14 objectives as very important. The top three objectives are: practical applications; investigative skills and processes; and attitudes appropriate to scientific endeavour. A high effectiveness rating by middle teachers is given for those objectives ranked as important.

13. Secondary level teachers rank 8 of the 14 objectives as very important. The top three objectives are: investigative skills and processes; practical applications; and attitudes appropriate to scientific endeavour. Secondary teachers feel they are the most effective in achieving the objective related to content.

14. The majority of early, middle, and secondary level teachers report "institutional arrangements" as the greatest obstacle to the achievement of science objectives. Three quarters of middle and secondary level teachers note that "students' abilities and interests" are an obstacle of concern.

15. Early level teachers rely heavily on Board curriculum materials and the school library for the purposes of instructional planning. Middle divison teachers rely on Board curriculum materials and approved textbooks, while secondary level teachers rely most on school-developed courses of study and provincially approved texts as major instructional resources.

16. Ministry guidelines are not extensively used as a resource in instructional planning in any teaching level.

17. The majority of teachers at the early and middle level feel that the amount of time allocated to science is "about right" or "adequate", relative to other subject disciplines. The majority of early teachers spend up to 2 hours teaching science per week, while middle teachers spend 2-3 hours weekly.

18. The majority of teachers at all three levels report frequent effective use of teacher directed instruction and small group investigation.

19. Evaluation at the early level is primarily based on informal observation. Middle level teachers favour the use of take-home examinations and projects or assignments, while secondary level teachers favour methods linked to tests and formal examinations.

20. There is minimal student involvement in the establishment of evaluation criteria for science in Peel.

21. Although science teachers are willing to participate in inservice programs, the majority of teachers at all levels are dissatisfied with the inservice programs in science. Teachers prefer time release to attend inservice programs.

22. Teachers at all levels believe that students are motivated to learn science. Teachers perceive no gender differences in motivation, ability, or achievement.

23. The majority of early level teachers rate physical facilities available for science as "poor" or "very poor".

EXECUTIVE SUMMARY - Principal, Superintendent and Resource Teacher Interviews/Surveys

The purpose of this portion of The Peel Board of Education Science Review was to interview principals, superintendents of schools, and resource teachers on their perceptions of the current state of science education in Peel. Interview questions related to teachers, students, curriculum, programming, inservice and leadership. A 20% sample of early level principals was selected from the various school organizations in the elementary panel (K-5, K-6, 6-8). For the middle principal interviews, a 20% sample was drawn from the following school organizations: K-8, 6-8, 7-8, 7-12/OAC. A total of 52 interviews were conducted at the elementary level. Twenty-eight secondary principal interviews were conducted, which included all the secondary (9-12/OAC, 7-12/OAC) and vocational schools (9-12). All superintendent of schools (11), including the Superintendent of Staff Development, were interviewed. Thirty resource teachers received a questionnaire via The Peel Board courier.

The instruments used in the interviews were developed largely from the findings of the teacher survey and were geared to the position and responsibilities of the respondents.

The major findings of each set of interviews is summarized below.

Early (K-6) and middle (7-8) level principals

1. Science is taught primarily by generalists at the early level.
2. Early level principals believe that a lack of science background has no impact on the teaching of science. Middle level principals believe that this has a negative impact on the teaching of science.
3. Early level principals and teachers identify the same three science objectives as important: social skills, attitudes appropriate to scientific endeavour, and investigative skills and processes. Middle level principals replace the social skills objective with the objective on relating scientific explanation to the student's conception of the world.

4. Early level principals report that the science facilities and resources in their schools are fair or good. Principals responsible for the middle level report that facilities are good and that resources are fair or good.

5. Early level principals differ with respect to the number of estimated hours per week that science is taught. Less than half of the principals report between 1-2 hours. Middle level principals report 2-3 hours.

6. Half of the early level principals and a majority of the middle level principals report that the time allocated to science is adequate to cover the curriculum.

7. Principals perceive no gender differences related to the enjoyment of science.

8. Half of the early level principals indicate the occurrence of less inservice in science relative to other subject disciplines, and they feel that more is required.

9. Early and middle level principals are unable to comment on the quality of regional science inservice.

10. Early and middle level principals report that resources are the item most requested by teachers in both levels.

11. Early and middle level principals feel that resource teachers provide less assistance in science, relative to the assistance provided by them in other subject disciplines.

Secondary principals

1. Minimal concensus is seen for secondary principals on interview questions related to objectives, obstacles, inservice, gender differences, and leadership.

2. Secondary principals report that most requests from science teachers are for improved facilities and equipment.

3. Secondary principals perceive no gender difference in relation to ability and achievement and are undecided in the case of motivation.

4. Secondary principals strongly support the idea that individual teachers should be responsible for lesson plans.

Superintendents of schools

1. Minimal concensus is noted for superintendents of schools on interview questions related to objectives, school requests, gender differences, and leadership.

2. Superintendents of schools unanimously report that teacher background and experience are obstacles to the achievement of science objectives in the classroom.

3. Superintendents of schools feel that male students are more motivated in science than female students. No gender differences are noted for student ability in science.

4. Superintendents of schools strongly support the idea that individual teachers should be responsible for lesson plans.

Resource teachers

1. Resource teachers report that the lack of teachers' science background has a negative impact at the primary, junior, and middle levels.

2. The majority of resource teachers detect discomfort by "science" teachers in the primary, junior, and middle levels, especially at the junior level.

3. Resource teachers rate the quality of the resources available for teaching science at all levels as poor or fair.

4. Resource teachers indicate that the time spent teaching science at the primary level is adequate, but that it is inadequate at the junior level. They can not respond to the question at the middle level.

5. Resource teachers report gender differences related to the enjoyment of science only at the middle level. They feel that male students enjoy science more than do female students.

6. Resource teachers report less inservice offered in science relative to other subject disciplines.

7. Resource teachers receive requests from "science" teachers for more inservice, improved facilities, and more resources.

EXECUTIVE SUMMARY - Review of Science Examinations and Written Curricula

Substudy 1. Review of Science Examinations

This sub-study of the Peel Science Review involved the analysis of a randomly selected sample of secondary school science examinations by a team of teachers trained for this task. These examinations were analyzed in two ways. First, each question was compared to the 14 objectives for science education used by The Science Council of Canada. (These findings were later reorganized into eight Aims of Science Teaching).

Second, each question was also classified according to the highest level of thinking required to answer it, using Bloom's Taxonomy as a basis for these ratings.

The major findings are summarized below:

1. The results are very similar across grades, across science subjects, and in semestered and non-semestered schools.
2. The examinations test primarily scientific knowledge. Skills, attitudes, career information, and personal growth objectives are seldom, if ever, tested.
3. There is very heavy concentration on recall and comprehension, with a significant amount of application in the form of quantitive problem solving, particularly in the physical sciences.

Substudy 2. Review of Written Curricula in Science

In this portion of the Peel Science Review, written curricula were analyzed by teams of teachers trained for the task. Using 14 objectives for science education (later reclassified into eight Aims of Science Teaching), the curricula were analysed for the presence or absence of a given objective. Curricula from three levels were analysed: Ministry guidelines (both "old" and "new"); Board curricula; and school plans. These documents were categorized as primary and junior (or early) level (K-6); middle level (7-8); and secondary level (9-13).

The major findings are summarized below:

1. Provincial curricula have been changed from the early 1960's to the present, broadening the definition of "science" from one of scientific knowledge and process to include a personal, social, and technological context for science.
2. Peel board-level curricula follow Ministry policy closely.
3. School plans show a significant difference between the early and secondary years. In the early years, both the quantity and quality of available plans are low. At the secondary level, planning is more complete and more sophisticated, but does not yet reflect recent changes in Ministry guidelines.

5. SURVEY REPORTS

5.1 STUDENT SURVEY

BACKGROUND AND RATIONALE

This study is one part of a larger two-year kindergarten-through-senior division review of science education in the Peel Board of Education (November 1986 - June, 1988). As part of the present study, students in grades 5, 9, and the senior division completed questionnaires on a variety of issues related to marks in science and mathematics, preference for these two areas of study, use of calculators and computers, future educational plans, science courses taken, pattern of doing homework, activities which occur during science learning, and attitudes toward school and science.

METHODOLOGY

This section describes the population and sample for each grade level, the instruments used at each grade level, the data collection procedures, and the types of statistical analyses carried out.

Grade 5: Population and Sample

The population from which the grade 5 student sample was drawn included all pupils registered in the grade 5 year in Peel elementary schools. Three types of school organizations in Peel offer grade 5 classes: kindergarten through grade 5 schools (K-5), kindergarten through grade 6 schools (K-6), and kindergarten through grade 8 schools (K-8). Approximately 42% of Peel schools offering grade 5 are K-5 schools, 43% are K-6 schools, and 15% are K-8 schools.

The student sample was selected to reflect these proportions. A total of 1,084 students were chosen: 455 (42%) from K-5 schools, 466 (43%) from K-6 schools, and 163 (15%) from K-8 schools. Schools were randomly selected within each school organization, for a total of 51 schools. Principals in each school were asked to select one grade 5 class using the following guidelines:

- no French Immersion classes were to be selected;
- no split-grade classes were to be selected, unless such a class was the only grade 5 grouping in the school;
- where there were multiple classes from which the principal could make a selection, he/she chose the class of that grade 5 teacher whose surname was listed second alphabetically among the grade 5 teachers in that school.

Grade 9: Population and Sample

The population from which the grade 9 sample was drawn included all students registered in grade 9 science courses in Peel; specifically, students registered in SNC 1A (advanced level), SNC 1G (general level), and SNC 1B (basic level). Data from Peel Computer Services indicated that during the 1986-87 school year, 4,379 students were registered in SNC 1A, 2,172 students in SNC 1G, and 750 students in SNC 1B. A total of 67 science classes were chosen for the final sample: 37 SNC 1A classes; 20 SNC 1G classes; and 10 SNC 1B classes. These classes included 1,353 grade 9 students.

All secondary schools were included in the sample. Where secondary schools indicated a SNC 1A population of greater than 175 pupils, two SNC 1A classes were chosen - classes of the second and third teachers alphabetically listed as teachers of SNC 1A. A total of 37 SNC 1A classes were included in the final sample.

The SNC 1G sample consisted of 20 classes selected from the 20 Peel secondary schools with the largest SNC 1G populations. In these 20 schools, the first class of the first teacher listed alphabetically as a teacher of SNC 1G was selected.

The SNC 1B sample consisted of 10 classes selected from the 10 Peel secondary schools showing the largest SNC 1B populations. In these 10 schools, the first section of the last teacher listed alphabetically as a teacher of SNC 1B was selected.

Senior Division: Population and Sample

The population from which the senior division sample was drawn consisted of all Peel students registered in the following courses during semester II of the 1986-87 school year:

SPH 3A/4A 3G/4G 5A (Physics);
SCH 3A/4A 3G/4G 5A (Chemistry);
SBI (XB1) 3A/3G 5A (Biology).

Proportionate samples were drawn for three groupings of students: those registered in advanced level science courses other than grade 13 (3A/4A); those registered in general level courses (3G/4G); and those registered in grade 13 courses (5A). The population of students registered in senior division basic level science courses was considered too small to include in the sample.

Data from Peel Computer Services indicated that 6,372 students were registered in advanced level science courses other than grade 13. The combined enrollment of students in senior division general level courses was 2,199; and the total number of students registered in grade 13 science courses was 3,754.

For this study, 65 senior division science classes were chosen: 34 from the group of advanced level courses other than grade 13; 11 from general level courses; and 20 from grade 13 courses. These classes contained 1,268 students.

A total of 34 advanced level science classes (excluding grade 13) were selected through a rotational sampling of schools. Thus, a biology course was selected (first teacher alphabetically) in the first school, a chemistry course in the second school, a physics course in the third, etc. The same process (but selecting the last teacher alphabetically) was used for designating 11 senior division general level science classes. This process was used again (but choosing the second teacher alphabetically) to select 20 grade 13 science classes.

Instrumentation: Overview

The instrument used in the present study was based in part on the measure utilized in the Second International Science Study (S.I.S.S.).[1] The instruments used at each grade level are briefly described below.

Grade 5 Instrument

The grade 5 instrument contained three sections. The first section contained 10 questions designed to obtain information on marks in science and mathematics, preference for science and mathematics, and the use of calculators and computers. The second section contained 18 attitudinal items which were categorized into three subscales: Attitude Toward School, Importance of Science, and Science as a school subject. Students expressed their opinions on these items using a 3-point scale (Agree-Uncertain-Disagree). The last section contained 10 items requiring students to describe the frequency (Often-Sometimes-Never) with which certain activities took place during science learning. A copy of the grade 5 instrument is included in Appendix A.

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[1] Permission was granted by Professor M. Connolly of The Ontario Institute for Studies in Education for the use of the S.I.S.S. instruments in the present study.

Grade 9 Instrument

The grade 9 instrument also contained three sections which were similar to the sections of the grade 5 measure. There were 17 items in the first section, 40 items in the second section, and 24 items in the third. Items in the second section were classified into four subscales: Attitude Toward School, Importance of Science, Science as a School Subject, and Careers in Science. Students responded to each statement on a 3-point scale (Agree-Uncertain-Disagree). A copy of the grade 9 student questionnaire is shown in Appendix B.

Senior Division Instrument

The senior division instrument contained three sections. The first section consisted of 23 questions on science and mathematics, calculators and computers, future educational plans, homework, etc. The second section contained 56 items classified into six subscales: Attitude Toward School, Importance of Science, Attitude Toward Biology, Attitude Toward Chemistry, Attitude Toward Physics, and Careers in Science.

Students were asked to indicate their attitudes using a 5-point scale (Strongly Agree-to-Strongly Disagree). The third section, which contained 24 items, referred to certain instructional activities during science classes. For a copy of the senior division questionnaire, see Appendix C.

Grade 5 Data Collection

Student questionnaires were distributed to principals on March 24, 1987. Teachers were asked to collect completed questionnaires from students in their classes and to return them to the Consultant: Evaluation at the Peel Research Unit by April 8, 1987. A total of 1,084 questionnaires were returned.

Grade 9 and Senior Division Data Collection

Student questionnaires were distributed to the heads of the science departments on April 28, 1987. They were requested to have individual teachers administer the questionnaires to specified classes and return them to the Consultant: Evaluation at the Peel Research Unit by May 20, 1987. A total of 1,353 completed grade 9 questionnaires were returned. Similar instructions were given for data collection at the senior divison level. A total of 1,268 completed questionnaires were returned.

Data Analysis

Responses for grade 5, 9 and senior division students were entered into the computer; frequency distributions, percentages and cross tabulations by gender were run.

In addition, items in the second section of each instrument (attitudinal items) were factor analyzed[1] by the method of principal components to determine whether a priori subscales in each measure could be identified. In the present case, vectors with eigenvalues greater than 1.00 were rotated by using the varimax procedure. Item analyses of each subscale were also carried out. These analyses yielded such statistics as item means and standard deviations, item subscale correlations, and overall subscale statistics (including alpha reliability coefficients).

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[1] Factor analysis is a data reduction technique which attempts to explain relationships among a large number of items in terms of a smaller number of factors or constructs.

RESULTS

Results for the three sections of the questionnaires are not presented in sequential order. The first and third section of each instrument dealt with issues which can be summarized in terms of frequencies; these results are presented first. The second section, which contained attitudinal subscales, involved psychometric analyses in addition to frequency distributions. The results of these more complex analyses are presented last.

Grade 5: Mathematics, Science, and Computing Aids

Table 1 presents the response frequencies for items about marks in science and mathematics, preference for science and mathematics, and the use of calculators and computers. Frequencies are broken down by gender in Table 2; results are shown only for those items on which there are significant gender differences at the .05 level, using a chi-square statistic.

Only 15% of the grade 5 students report that their science marks are better than those in their other school subjects. The majority of these students (76%) feel that their science marks are about average, compared to their other subjects. There are no significant gender differences in perceptions about science marks. The findings are quite different in the case of mathematics marks. Forty percent of the students indicate that their mathematics marks are better than marks in other school subjects, and another 48% feel that their mathematics marks are average, compared to their other subjects. A significantly larger proportion of boys than girls believe that their mathematics marks are better than other subjects. Conversely, girls are more likely to indicate that their mathematics marks are average, compared to their other marks.

Mathematics seems to be more popular than science with grade 5 students. Almost half of the students (48%) indicate that they like mathematics more than most other school subjects, compared to only 27% who feel this way about science. In both cases, a larger proportion of boys than girls say they like science and mathematics more than other school subjects.

A majority of the students report that they do not have calculators for use at school (79%), but that they do have calculators at home (88%). Almost every student (96%) reports having access to a computer at school; however, most students either "never" use the computer (21%) or use it only "up to 2 hours" per week (72%). Half of the students (49%) report that they have a computer at home; more boys (54%) than girls (44%) respond "yes" to this question.

Table 1

Grade 5: Response Frequencies of Items about School Marks, Preference for Science and Mathematics, and Use of Calculators and Computers

Item	n	%
Science Marks		
-better than other subjects.	167	15
-average compared to other subjects.	815	76
-worse than other subjects.	90	8
Mathematics Marks		
-better than other subjects.	430	40
-average compared to other subjects.	518	48
-worse than other subjects.	127	12
Like Science		
-more than most other subjects.	290	27
-about the same as other subjects.	578	53
-less than most other subjects.	208	19
Like Mathematics		
-more than most other subjects.	517	48
-about the same as other subjects.	370	34
-less than most other subjects.	182	17
Calculator At School For Use		
-yes	216	20
-no	859	79
Have Calculator At Home		
-yes	951	88
-no	123	11
Computer At School For Use		
-yes	1,036	96
-no	40	4
Weekly Time Spent On Computer		
-never.	224	21
-up to 2 hours.	779	72
-3-5 hours.	29	3
-6-10 hours.	5	1
-more than 10 hours.	5	1
Have Computer At Home		
-yes	527	49
-no	549	51

Table 2

Grade 5: Response Frequencies of Items with Significant Gender Differences: Marks, Preference for Science and Mathematics, and Use of Calculators and Computers

Item	Boys		Girls	
	n	%	n	%
Mathematics Marks				
-better than other subjects.	242	44	188	36
-average compared to other subjects.	249	45	269	52
-worse than other subjects.	63	11	64	12
Like Science				
-more than most other subjects.	182	33	108	21
-about the same as other subjects.	272	49	306	59
-less than most other subjects.	101	18	107	20
Like Mathematics				
-more than most other subjects.	284	52	233	45
-about the same as other subjects.	185	33	185	36
-less than most other subjects.	81	15	101	19
Have Computer At Home				
-yes	300	54	227	44
-no	254	46	295	56

Grade 5: Activities During Science Learning

Response frequencies of items related to activities during science learning are presented in Table 3.

Sixty-one percent of the students indicate that they "never" use a textbook, but most students "sometimes" (62%) or "often" (26%) use library books for learning science. Approximately half of the students report that "sometimes" they are given the opportunity to choose topics (48%), provide ideas and suggestions in planning science lessons (55%), watch the teacher perform experiments (49%), and conduct experiments themselves as part of the science lessons (54%). About two thirds of the students indicate that "sometimes" (44%) or "often" (19%) the class is divided into small groups to do experiments during science lessons. Most of the students (86%-91%) report that "sometimes" or "often" they copy the teacher's notes from the blackboard into their own notebooks, have tests on what they have learned in science, and find that their teachers make science lessons interesting for them.

There are no significant gender differences for any of these activities.

Table 3

Grade 5: Response Frequencies of Items about Activities During Science Classes

Item Statement	Often		Sometimes		Never	
	n	%	n	%	n	%
We use a textbook for our science lessons.	146	14	270	25	658	61
We use library books for learning science.	285	26	672	62	115	11
We choose the topics we want to study in science.	97	9	516	48	450	42
The teacher uses our ideas and suggestions when planning science lessons.	183	17	596	55	292	27
We watch the teacher do experiments during our science lessons.	181	17	526	49	362	33
The teacher makes science lessons interesting for us.	625	58	361	33	85	8
During science lessons we copy the teacher's notes from the blackboard into our own books.	548	51	437	40	83	8
We have tests on what we have learned in science.	448	41	487	45	135	13
The students in this class do experiments as part of the science lessons.	248	23	588	54	232	21
The class breaks into small groups of students to do experiments during science lessons.	205	19	477	44	388	36

Grade 5: Attitude Toward School Subscale

This, and the following sections of the grade 5 results deal with the second part of the questionnaire -- the 18 attitudinal items which are divided into three subscales: Attitude Toward School, Importance of Science, and Science as a School Subject.

Response frequencies of items in the Attitude Toward School subscale are presented in Table 4; item means, item standard deviations, and item-subscale correlations are summarized in Table 5.

A majority (74%-88%) of the students agree that they find school interesting, enjoy most things about school, and would like to get as much education as possible. This positive outlook is confirmed by a majority (64%-71%) of students who disagree with statements about disliking their school work, not enjoying school, being bored in school, and disliking many school subjects. However, only about half of the students (52%) agree that time spent at school is the most enjoyable part of their lives.

The lowest item mean (1.72) is for the statement: "The most enjoyable part of my life is the time I spend at school." Although these students want to get as much education as they can (the highest item mean, 2.84), time spent in school is not seen as the best part of their lives. These two items also have the lowest item-subscale correlations, indicating that they have much less in common with the total subscale score than is true for the other items.

Table 4

Grade 5: Response Frequencies of Items in the Attitude Toward School Subscale

Item Statement	Agree		Uncertain		Disagree	
	n	%	n	%	n	%
I find school interesting.	806	74	136	13	129	12
I generally dislike my school work.	162	15	166	15	735	68
School is not very enjoyable.	177	16	121	11	767	71
I want as much education as I can get.	952	88	81	8	42	4
I enjoy most things about school.	872	80	103	10	98	9
I am bored most of the time in school.	215	20	114	10	736	68
There are many school subjects I don't like.	277	26	100	9	690	64
The most enjoyable part of my life is the time I spend at school.	270	25	236	22	568	52

Table 5

Grade 5: Summary Statistics for Items in the Attitude Toward School Subscale

Item Statement	M	SD	Item-Subscale Correlation
I find school interesting.	2.62	.69	.61
I generally dislike my school work.	2.53	.74	.55
School is not very enjoyable.	2.54	.76	.62
I want as much education as I can get.	2.84	.46	.29
I enjoy most things about school.	2.71	.62	.58
I am bored most of the time in school.	2.48	.80	.56
There are many school subjects I do not like.	2.38	.86	.57
The most enjoyable part of my life is the time I spend at school.	1.72	.84	.37

Grade 5: Importance of Science Subscale

Response frequencies of items in the Importance of Science subscale are summarized in Table 6, followed by item statistics in Table 7.

A sizeable number of the students (69%-74%) agree that science is important in making the world a better place, in making our lives easier, and in facilitating a country's development. However, only half of the students feel that the government should extend financial help to scientists. A sizeable proportion of the students do not feel that scientific discoveries are harmful (62%), nor that science has ruined the environment (71%). Grade 5 students may be too young to be fully aware of the potentially harmful impact of technology on the environment.

Item means in Table 7 range from 2.30 ("The government should spend more money on helping scientists") to 2.66 ("Science will help to make the world a better place in the future"). Although these students recognize the importance of science, they are not as positive about the idea of government support for scientists. The item on government aid to scientists also has the lowest item-subscale correlation (.21), indicating that it is measuring a somewhat different construct than the other items in the scale.

Table 6

Grade 5: Response Frequencies of Items in the Importance of Science Subscale

Item Statement	Agree		Uncertain		Disagree	
	n	%	n	%	n	%
Scientific discoveries make our lives easier.	749	69	247	23	65	6
Science has ruined the environment.	75	7	210	19	771	71
Science will help to make the world a better place in the future.	783	72	229	21	63	6
Scientific discoveries do more harm than good.	80	7	322	30	667	62
Science is very important for a country's development.	805	74	217	20	50	5
The government should spend more money on helping scientists.	534	49	320	30	213	20

Table 7

Grade 5: Summary Statistics for Items in the Importance of Science Subscale

Item Statement	M	SD	Item-Subscale Correlation
Scientific discoveries make our lives easier.	2.63	.59	.37
Science has ruined the environment.	2.64	.61	.33
Science will help to make the world a better place in the future.	2.66	.58	.44
Scientific discoveries do more harm than good.	2.54	.63	.37
Science is very important for a country's development.	2.70	.55	.43
The government should spend more money on helping scientists.	2.30	.78	.21

Grade 5: Science as a School Subject Subscale

Response frequencies and item statistics for the Science as a School Subject subscale are shown in Tables 8 and 9.

Most students affirm that science is an enjoyable (68%) and interesting (73%) subject. About half of the students disagree with statements maintaining that science is a "difficult subject" (52%) and full of "too many facts" (51%). These two negatively worded statements have the lowest means and item-subscale correlations.

Table 8

Grade 5: Response Frequencies of Items in the Science as a School Subject Subscale

Item Statement	Agree		Uncertain		Disagree	
	n	%	n	%	n	%
Science is an enjoyable school subject.	735	68	180	17	157	14
The science taught at school is interesting.	790	73	145	13	131	12
Science is a difficult subject.	270	25	229	21	565	52
There are too many facts to learn in science.	295	27	219	20	549	51

Table 9

Grade 5: Summary Statistics for Items in the Science as a School Subject Subscale

Item Statement	M	SD	Item-Subscale Correlation
Science is an enjoyable school subject.	2.53	.73	.46
The science taught at school is interesting.	2.61	.69	.39
Science is a difficult subject.	2.27	.83	.29
There are too many facts to learn in science.	2.23	.85	.35

Grade 5: Gender Differences

The three attitudinal subscales were also analyzed to determine any gender differences in response patterns. No significant gender differences emerge for the Science as a School Subject subscale. Gender differences are seen for the Attitude Toward School and Importance of Science subscales. Table 10 presents the items in these two subscales on which there are significant differences, as well as the percentages for boys and girls. For the Attitude Toward School subscale, girls express more positive attitudes than boys on every item shown in Table 10. However, on most items in the Importance of Science subscale, boys respond more positively than girls.

Table 10

Grade 5: Percent Response Frequencies of Items with Significant Gender Differences: Attitude Toward School, Importance of Science, and Science as a School Subject[a]

Subscale/Item	Boys			Girls		
	Agree %	Uncertain %	Disagree %	Agree %	Uncertain %	Disagree %
Attitude Toward School						
-school is interesting	71	14	15	80	12	8
-dislike school work	17	19	64	14	12	74
-school not enjoyable	21	13	66	12	10	78
-enjoy school	76	12	12	87	7	6
-bored at school	25	12	63	15	10	75
-don't like subjects	32	11	57	19	8	73
-enjoyable part of life is time spent at school	19	20	61	31	24	45
Importance of Science						
-scientific discoveries make life easier	76	18	6	65	29	6
-science makes the world a better place	79	16	5	66	27	7
-science harmful	10	26	64	5	35	60
-science important for development	81	14	5	69	27	4
-government helping scientists	56	25	19	44	35	21

[a] None of the four items in the Science as a School Subject subscale yields significant gender differences.

Grade 5: Overall Item Analyses

Means, standard deviations, alpha reliability coefficients, and correlations among the subscale scores are presented in Table 11.

The magnitude of the mean scores -- about 80% of the maximum possible scores on the three subscales -- indicates that as a group the grade 5 students have a favourable attitude toward school, value science, and like science as a school subject.

The alpha reliability coefficients are .80 (Attitude Toward School), .62 (Importance of Science), and .58 (Science as a School Subject); the reliability coefficient of the total score, based on 18 items, is .78. Considering the small number of items and the age of the respondents, these reliability coefficients are acceptable.

The intercorrelations among the three subscale scores range from .15 to .35. These values are in the moderate range, indicating that the subscales measure three distinct characteristics.

Table 11

Grade 5: Means, Standard Deviations, Alpha Reliability Coefficients, and Correlations Among the Subscales

Subscale	1	2	3	Total Score
1. Attitude Towards School		.15	.35	.83
2. Importance of Science			.27	.57
3. Science as a School Subject				.69
Maximum Possible Score	24.00	18.00	12.00	54.00
Mean	19.84	15.47	9.65	44.96
Standard Deviation	3.80	2.20	2.08	5.84
Alpha Reliability	.80	.62	.58	.78

Grade 5: Factor Analysis of the Attitude Scale

Results of the factor analysis of the 18 attitude items are shown in Table 12.

Since there were five eigenvalues greater than 1.00 (ranging from 1.02 to 3.95), five components were rotated to achieve a simple structure. Items which relate to school load on the first factor, except for the statement, "I want as much education as I can get," which does not have loadings of .40 or greater on any factor. An examination of this item reveals that it does not deal directly with school, but rather with educational goals. All other items designed to assess attitude towards school emerge on a single factor.

The second and third factors contain items relating to the importance of science. The four positively worded items (items 3, 10, 15, and 17) load on the second factor, and the two negatively worded items (items 5 and 12) load on the third factor. For practical purposes, these two factors can be collapsed into a single factor, namely, the importance of science.

The situation is similiar for items relating to science as a school subject. Positively worded items load on the fourth factor, and negatively worded items load on the fifth factor. Again, these two factors can be combined into one factor, science as a school subject. The results of the factor analysis indicate that the 18 attitude items do, in fact, assess three separate constructs: attitude toward school, the importance of science, and science as a school subject.

The communality of an item indicates the extent to which it is related to other items. In other words, it is the amount of variance associated with an item which is accounted for by the total number of factors. The communalities (h2) for these 18 items range from .32 to .76, indicating that a significant amount of variance in most of the items has been extracted.

Table 12

Grade 5: Rotated Factor Loadings and Communalities of Items in the Attitude Scale[a]

Item Statement	I	II	III	IV	V	h^2
Science is an enjoyable school subject.				.82		.76
I find school interesting.	.74					.59
Scientific discoveries make our lives easier.		.64				.42
I generally dislike my schoolwork.	-.64					.49
Science has ruined the environment.			.70			.52
The science taught at school is interesting.				.84		.76
School is not very enjoyable.	-.75					.62
Science is a difficult subject.					.80	.66
I want as much education as I can get.						.32
Science will help to make the world a better place in the future.		.63				.54
I enjoy most things about school.	.70					.57
Scientific discoveries do more harm than good.			.72			.59
I am bored most of the time in school.	-.65					.55
There are too many facts to learn in science.					.68	.51
Science is very important for a country's development.		.68				.52
There are many school subjects I don't like.	-.66					.60
The government should spend more money on helping scientists.		.55				.41
The most enjoyable part of my life is the time I spend at school.	.47					.34

[a] Factor loadings less than absolute .40 are not reported. Communality of an item is indicated by h^2.

Grade 5: Summary

Three quarters of the grade 5 students rate their science marks as "average," compared to their marks in other school subjects; about half of the students feel that their mathematics marks are average in relation to marks in other subjects. Mathematics appears to be a more popular subject then science among grade 5 students. More boys than girls express a preference for mathematics and science, compared to other school subjects. Most students have calculators for use at home, and almost every student has access to a computer at school. About half of the students (more boys than girls) say they have a computer at home.

Most of the students say they do not use a science textbook, although occasionally they use library books in learning science. Sometimes students are given an opportunity to choose science topics, provide ideas and suggestions, watch teachers do experiments, and perform experiments themselves. Most of the students copy teachers' notes from the blackboard and have tests on what they have learned in science. Most students also feel that their teachers make science lessons interesting, and that science is an enjoyable and interesting subject.

In general, most grade 5 students find school interesting, and they wish to get as much education as possible. Two out of three students say that they don't dislike school work, nor do they find school boring. More girls than boys express positive attitudes toward school.

A majority of the students agree that science is important to their lives, in making the world a better place, and in a country's development. These students feel that science is very important to mankind, and do not believe that scientific discoveries are harmful to the environment. More boys than girls give positive responses about the importance of science.

The factor analysis of the 18 items in the attitude scale yields three factors, which reflect the three subscales determined on a conceptual basis: Attitude Toward School, Importance of Science, and Science as a School Subject. In addition, the overall psychometric analyses indicate that the three subscales are reliable, considering the comparatively small number of items in each subscale.

Grade 9: Mathematics, Computing Aids, and Homework

Response frequencies of grade 9 student responses to questions on marks in science and mathematics, preference for science and mathematics, use of computing aids, and homework are presented in Table 13.

Approximately one fifth of the grade 9 students (22%) report that their science marks are better than the marks in other subjects. About one third indicate that their marks in mathematics are better than in other subjects. For both science and mathematics, one fourth of the students feel that their marks are worse than marks in other subjects. Significant gender differences emerge on these items, with more boys than girls reporting that their marks in science and mathematics are better than in other subjects.

A majority of the students say they like science (77%) and mathematics (69%) more than or the same as other subjects. Gender differences emerge with respect to preference for these two subjects: boys are more likely than girls to say they like science and mathematics more than other school subjects.

Most grade 9 students have a calculator available for use at school (82%) or at home (95%). About half of the students (46%) have a computer at home. Although 85% of the students report having access to a computer at school, 80% say they have never used it. Only 10% of the grade 9 students are taking or have taken a computer course. Boys and girls show no differences in their responses to questions about the use of calculators or access/use of computers at school. However, more boys than girls indicate that they have computers at home.

Almost all of the students plan to finish at least grade 12, and 58% plan one or more years of post-secondary education. However, about one third of the students are "undecided" about education after high school. Approximately 4 out of 10 students plan to include science in their post-secondary studies. No gender differences are seen in response patterns to these questions.

A majority of the students (81%) spend between 2 and 10 hours per week on homework; 9% say they spend more than 11 hours per week on homework, while another 9% indicate that they spend no time on homework. With respect to science homework specifically, a majority of the students (61%) spend up to 2 hours per week; 21% report spending 3 to 10 hours per week, and 2% spend more than 10 hours per week. Fourteen percent say they do no science homework. With respect to gender differences on these homework questions, more girls than boys spend time on homework generally, and on homework in science, specfically.

Table 13

Grade 9: Response Frequencies of Items on School Marks, Preference for Mathematics and Science, Use of Calculators and Computers, Future Educational Plans, and Homework

Item	n	%
Science Marks		
-better than others	296	22
-average	684	51
-worse than others	345	26
Mathematics Marks		
-better than others	455	34
-average	540	40
-worse than others	330	24
Like Science		
-more than other courses	347	26
-same as other courses	688	51
-less than other courses	296	22
Like Mathematics		
-more than other courses	362	27
-same as other courses	568	42
-less than other courses	405	30
Use Calculator At School		
-yes	1,106	82
-no	212	16
Have Calculator At Home		
-yes	1,283	95
-no	52	4
Computer At School For Use		
-yes	1,148	85
-no	174	13
Time Spent Using Computer		
-never	1,075	80
-up to 2 hours	184	14
-3 - 5 hours	53	4
-6 - 10 hours	9	1
-10+ hours	9	1
Have A Computer At Home		
-yes	622	46
-no	712	53
Taking or Taken A Computer Course		
-yes	139	10
-no	1,190	88

continued . . .

Table 13, Continued

Item	n	%
Last Grade In High School		
-grade 10	36	3
-grade 11	9	1
-grade 12	413	30
-grade 13	863	64
Years Of Education After High School		
-none	65	5
-1 - 2 years	121	9
-3 - 4 years	327	24
-4+ years	334	25
-undecided	486	36
Expect To Include Science In Further Studies		
-expect to include science	550	41
-do not expect to include science	240	18
-do not expect to continue education	40	3
-not decided as yet	501	37
Hours Per Week On Homework		
-none	121	9
-up to 2 hours	426	32
-3 - 5 hours	392	29
-6 - 10 hours	269	20
-11 - 20 hours	94	7
-20+ hours	28	2
Hours Per Week On Science Homework		
-none	193	14
-up to 2 hours	822	61
-3 - 5 hours	228	17
-6 - 10 hours	53	4
-10+ hours	25	2

Grade 9: Activities During Science Learning

Response frequencies of items relating to activities during science classes are presented in Table 14.

Almost all students agree that they use a textbook during science classes "sometimes" or "often" (93%). About one third of the students (32%) indicate that they "sometimes" use books other than textbooks, although 57% "never" use books other than textbooks. The students report that at the start of each science class, the teacher "sometimes" or "often" reminds them about the work covered in previous classes and explains the work to be covered during the current class (88%). A majority of the students (70%) also note that at the end of the science class the science teacher "sometimes" or "often" summarizes the lesson.

A majority of the students are "never" allowed to choose their own science topics to study (80%), or to make up their own laboratory problems (65%). However, 42% of the students report that "sometimes" or "often" the teacher uses their ideas and suggestions in planning science classes.

A sizeable percentage of students indicate that "sometimes" or "often" the teacher uses demonstrations when explaining scientific ideas (94%) and tries to make science classes interesting (85%). In addition, a majority of the students "sometimes" or "often" copy teachers's notes from the blackboard (91%), write up reports of laboratory experiments and practical work as their science homework (80%), and have tests in science (95%). About half of the students (55%) "sometimes" or "often" use calculators in science class.

About three quarters of the students (73%) state that the teacher "sometimes" or "often" discusses the relevance of science to everyday life, but less often talks about possible careers in science (41%). Most students (80%) say that they "never" have an opportunity to work outside the classroom as part of science learning. Students "sometimes" or "often" do laboratory work as part of science classes (90%) and break into small groups for this work (86%), guided by the teacher (92%) or by written instructions (82%). A majority (87%) also note that the science teacher "sometimes" or "often" helps students who are having difficulties with learning science.

There are significant differences between boys and girls in how they perceive the activities which take place during science learning. These differences especially appear on statements which relate to activities involving choice. For instance, relatively more girls than boys report that they never use other books; that the teacher never uses their ideas or suggestions; that the teacher never discusses possible careers in science; that they never do field work; and that they never make up their own laboratory problems and then solve them with the help of the teacher.

Table 14

Grade 9: Response Frequencies of Items About Activities During Science Classes

Item Statement	Often		Sometimes		Never	
	n	%	n	%	n	%
We use a textbook during science classes.	871	64	391	29	65	5
We use books other than textbooks for learning science.	125	9	428	32	767	57
At the start of each science class the teacher reminds us about the work we covered during previous classes.	543	40	654	48	123	9
At the start of each science class the teacher explains the work we have to cover during the class.	655	48	543	40	121	9
At the end of each science class the teacher gives a summary of what was taught in the class.	276	20	670	50	376	28
We are allowed to make our own choice of science topics to study.	49	4	191	14	1,078	80
The teacher uses our ideas and suggestions when planning science classes.	94	7	474	35	742	55
The teacher does demonstrations to help explain scientific ideas.	728	54	540	40	48	4
The teacher makes science classes interesting for us.	536	40	603	45	165	12
During science classes we copy the teacher's notes from the blackboard into our own books.	654	48	575	43	87	6
For science homework we write up reports of our laboratory and practical work.	508	38	571	42	230	17

continued . . .

Table 14, Continued

Item Statement	Often		Sometimes		Never	
	n	%	n	%	n	%
The teacher explains how the science we learn is relevant to our own lives.	350	26	641	47	316	23
The teacher discusses possible careers in science with us.	97	7	457	34	759	56
We have tests on what we have learned in science.	1,108	82	180	13	19	1
The science teacher helps students who have difficulties with learning science.	670	50	500	37	136	10
We use calculators during science classes.	191	14	548	41	575	43
We do field work outside the classroom as part of our science classes.	20	2	209	15	1,080	80
We do laboratory work as part of our science classes.	716	53	495	37	96	7
The science class breaks into small groups of students to do laboratory work.	809	60	354	26	147	11
When we do laboratory work the teacher gives us instructions about what to do.	1,033	76	220	16	56	4
When we do laboratory or field work we use a book or other written instructions to show us how to do it.	694	51	417	31	200	15
In our laboratory or field work we make up our own problems and then the teacher helps us to plan experiments to solve them.	105	8	316	23	887	65

continued . . .

Table 14, Continued

Item Statement	Often		Sometimes		Never	
	n	%	n	%	n	%
When we do laboratory or field work the teacher gives us problems to solve and then leaves us to work out our own methods and solutions.	314	23	641	47	352	26
In our laboratory or field work we make up our own problems and work out our own methods to investigate the problems.	113	9	299	22	897	66

Grade 9: Attitude Toward School Subscale

This, and the following sections of the grade 9 findings deal with the second section of the grade 9 survey -- the 40 attitudinal items which are divided into four subscales: Attitude Toward School, Importance of Science, Science as a School Subject, and Careers in Science.

Table 15 presents the response frequencies of items for the Attitude Toward School subscale, followed by item statistics in Table 16.

About two out of three students find school challenging (67%) and want to get as much education as they can get (71%). However, they disagree that they enjoy everything about school (69%), including spending time at school (66%). Approximately, half of the students disagree with statements that school is not very enjoyable (50%), that school is boring (49%), and they dislike school work (46%). However, about half of the students (47%) also agree that there are many school subjects that they don't like.

Table 16 shows summary statistics for this subscale. Item means range from 1.46 ("I enjoy everything about school") to 2.62 ("I want as much education as I can get"). The item-subscale correlations range from .23 to .60, indicating a moderate-to-high relationship of items with the total score on the subscale.

On all but two items in this subscale, girls demonstrate a more positive attitude toward school than boys. The two exceptions (for which no gender differences emerge) are: "I am bored most of the time in school" and "I want as much education as I can get."

Table 15

Grade 9: Response Frequencies of Items in the Attitude Toward School Subscale

Item Statement	Agree		Uncertain		Disagree	
	n	%	n	%	n	%
I find school challenging.	910	67	177	13	242	18
School is not very enjoyable.	420	31	233	17	676	50
I enjoy everything about school.	202	15	187	14	934	69
I am bored most of the time in school.	479	35	178	13	665	49
There are many school subjects I don't like.	638	47	112	8	578	43
The most enjoyable part of my life is the time I spend at school.	210	16	209	15	900	66
I want as much education as I can get.	965	71	238	18	125	9
I generally dislike my schoolwork.	470	35	231	17	625	46

Table 16

Grade 9: Summary Statistics for Items in the Attitude Toward School Subscale

Item Statement	M	SD	Item-Subscale Correlation
I find school challenging.	2.49	.78	.23
School is not very enjoyable.	2.19	.88	.59
I enjoy everything about school.	1.46	.74	.39
I am bored most of the time in school.	2.14	.91	.55
There are many school subjects I don't like.	1.96	.95	.50
The most enjoyable part of my life is the time I spend at school.	1.49	.75	.30
I want as much education as I can get.	2.62	.65	.33
I generally dislike my schoolwork.	2.12	.89	.60

Grade 9: Importance of Science Subscale

Tables 17 and 18 include response frequencies and summary statistics for items in the Importance of Science subscale.

A majority of students (70% - 82%) agree that they want to learn more about the world they live in; that scientific inventions improve their standard of living; and that science is important for a country's development. Slightly more than half of the students agree that science is useful for solving everyday problems (58%); that science will help make the world a better place in the future (57%); and that science is relevant to everyday life (53%). Although about half of the students (53%) feel that, in general, "money spent on science is well worth spending," they tend to be uncertain (49%) about whether public money spent on science "in the last few years" has been used wisely.

A sizeable number of students (50% - 62%) disagree that science has made the world too complex; that scientific discoveries do more harm than good; and that science has ruined the environment. There is no clear trend in the responses to these statements: "Science and technology are the causes of many of the world's problems;" "Scientific inventions have increased tensions between people;" and "Much of the anxiety in modern society is due to science."

The item means (Table 18) range from 1.91 ("Scientific inventions have increased tensions between people") to 2.76 ("Science is very important for a country's development"). The item "Much of the anxiety in modern society is due to science" has only a .07 correlation with the total Importance of Science score; however, the other items have acceptable correlations with the total subscale score.

Except for the item "Science is relevant to everyday life," there are significant gender differences on all items in this subscale. For all but one item, more boys than girls tend to agree with the positive statements. For the item relating to the expenditure of public money on science, more boys than girls disagree, and more girls than boys express uncertainty. However, more girls than boys disagree that science has ruined the environment and that much of the anxiety in the modern world is due to science. Although more boys than girls disagree that scientific inventions have made the world too complex, they do agree that scientific inventions have increased tensions between people, and that science and technology cause many world problems.

There seem to be no clear-cut patterns among boys and girls regarding their feelings about the importance of science. Girls are less likely than boys to emphasize the importance of science; however, they do not assign negative attributes to science. Although boys consider science to be important, they do agree that science may be causing some of the problems in the modern world.

Table 17

Grade 9: Response Frequencies of Items in the Importance of Science Subscale

Item Statement	Agree		Uncertain		Disagree	
	n	%	n	%	n	%
Science is useful for solving the problems of everyday life.	778	58	333	25	224	17
Science has ruined the environment.	170	13	298	22	846	62
Science is very important for a country's development.	1,105	82	153	11	72	5
Money spent on science is well worth spending.	710	53	410	30	207	15
Much of the anxiety in modern society is due to science.	367	27	598	44	362	27
Public money spent on science in the last few years has been used wisely.	406	30	661	49	248	18
Scientific inventions improve our standard of living.	1,007	74	222	16	82	6
The government should spend more money on scientific research.	464	34	542	40	317	23
Scientific inventions have made the world too complex.	298	22	350	26	673	50
Scientific inventions have increased tensions between people.	447	33	554	41	324	24
Science will help to make the world a better place in the future.	771	57	386	28	169	12

continued . . .

Table 17, Continued

Item Statement	Agree		Uncertain		Disagree	
	n	%	n	%	n	%
Scientific discoveries do more harm than good.	122	9	481	36	716	53
Science and technology are the causes of many of the world's problems.	444	33	452	33	415	31
I want to learn more about the world we live in.	945	70	222	16	156	12
Science is relevant to everyday life.	723	53	371	27	230	17

Table 18

Grade 9: Summary Statistics for Items in the Importance of Science Subscale

Item Statement	M	SD	Item-Subscale Correlation
Science is useful for solving the problems of everyday life.	2.41	.76	.28
Science has ruined the environment.	2.50	.71	.38
Science is very important for a country's development.	2.76	.54	.31
Money spent on science is well worth spending.	2.37	.74	.47
Much of the anxiety in modern society is due to science.	2.00	.73	.07
Public money spent on science in the last few years has been used wisely.	2.12	.69	.32
Scientific inventions improve our standard of living.	2.68	.58	.32
The government should spend more money on scientific research.	2.11	.75	.36
Scientific inventions have made the world too complex.	2.28	.80	.42
Scientific inventions have increased tensions between people.	1.91	.75	.23

continued . . .

Table 18, Continued

Item Statement	M	SD	Item-Subscale Correlation
Science will help to make the world a better place in the future.	2.44	.70	.47
Scientific discoveries do more harm than good.	2.44	.65	.48
Science and technology are the causes of many of the world's problems.	1.98	.80	.32
I want to learn more about the world we live in.	2.58	.69	.26
Science is relevant to everyday life.	2.36	.76	.30

Grade 9: Science as a School Subject Subscale

Tables 19 and 20 present response frequencies and summary statistics for items in the Science as a School Subject subscale.

About three quarters of the students agree that science can be learned by almost any student if properly instructed, and disagree that handling apparatus in science is difficult. About half of the students agree that science is an enjoyable (50%) and interesting (53%) school subject, but that there are too many facts to learn (52%). Fewer than half of the students feel that science is difficult (43%), especially when it involves handling calculations (46%).

As shown in Table 20, the item means range from 1.82 ("There are too many facts to learn in science") to 2.62 ("Science is difficult when it involves handling apparatus"). All but one item have acceptable item-subscale correlations; the exception is: "If properly taught, almost all students could learn science" (.17).

There are significant gender differences on all but one item in this subscale. Boys are less likely than girls to feel that there are too many facts in science, that it is a difficult subject, or that calculations and handling apparatus make science more difficult. In addition, more boys than girls consider science an enjoyable and interesting area of study. Boys and girls do not differ on the item: "If properly taught, almost all students could learn science."

Table 19

Grade 9: Response Frequencies of Items in the Science as a School Subject Subscale

Item Statement	Agree		Uncertain		Disagree	
	n	%	n	%	n	%
If properly taught, almost all students could learn science.	996	74	137	10	186	14
Science is an enjoyable school subject.	671	50	288	21	358	27
The science taught at school is interesting.	718	53	261	19	332	25
Science is a difficult subject.	580	43	231	17	500	37
Science is difficult when it involves calculations.	615	46	185	14	521	38
Science is difficult when it involves handling apparatus.	164	12	158	12	1,000	74
There are too many facts to learn in science.	698	52	166	12	455	34

Table 20

Grade 9: Summary Statistics for Items in the Science as a School Subject Subscale

Item Statement	M	SD	Item-Subscale Correlation
If properly taught, almost all students could learn science.	2.60	.72	.17
Science is an enjoyable school subject.	2.23	.84	.49
The science taught at school is interesting.	2.28	.83	.44
Science is a difficult subject.	1.94	.89	.44
Science is difficult when it involves calculations.	1.93	.91	.30
Science is difficult when it involves handling apparatus.	2.62	.69	.25
There are too many facts to learn in science.	1.82	.91	.47

Grade 9: Careers in Science Subscale

Response frequencies and summary statistics for items in the Careers in Science subscale are given in Tables 21 and 22.

Very few (3%) of the students agree that they would like to become science teachers; most of them (83%) disagree with this idea. About two out of three students agree that science is a good field for creative people to enter, and 60% feel that future jobs will require knowledge of science. Slightly fewer than half of the students (46%) feel that a job in a science laboratory would be an interesting one, and also that scientists are responsible for the ways in which their discoveries are applied. Half of the students disagree with the idea that "people who work with modern inventions such as computers have more interesting jobs." The remaining three items in the subscale show no definite response trends.

The item means (Table 22) range from 1.19 ("I would like to become a science teacher") to 2.56 ("Science is a very good job field for creative people to enter"). The correlations for the last two statements in the subscale (.12 and .10, respectively) indicate that they have nothing in common with the total Careers in Science subscale score.

There are no significant gender differences on these three items: "Working in a science laboratory would be an interesting way to earn a living;" "In the future most jobs will require a knowledge of science;" and "I would like to become a science teacher when I leave school." Significantly more girls than boys are uncertain about whether scientists are responsible for the application of their discoveries. Boys are more likely than girls to agree with the remaining five items in the subscale. On the whole, more boys than girls express postive attitudes toward careers in science.

Table 21

Grade 9: Response Frequencies of Items in the Careers in Science Subscale

Item Statement	Agree		Uncertain		Disagree	
	n	%	n	%	n	%
Working in a science laboratory would be an interesting way to earn a living.	618	46	294	22	419	31
In the future most jobs will require a knowledge of science.	814	60	325	24	194	14
People who understand science are better off in our society.	454	34	383	28	491	36
It is important to know science in order to get a good job.	443	33	326	24	558	41
Science is a very good field for creative people to enter.	919	68	251	19	157	12
In my future career I would like to use the science I learned at school.	484	36	471	35	366	27
People who work with modern inventions such as computers have more interesting jobs.	383	28	269	20	677	50
I would like to become a science teacher when I leave school.	36	3	167	12	1,126	83
Scientists are responsible for the way in which their discoveries are applied.	619	46	455	34	245	18

Table 22

Grade 9: Summary Statistics for Items in the Careers in Science Subscale

Item Statement	M	SD	Item-Subscale Correlation
Working in a science laboratory would be an interesting way to earn a living.	2.15	.86	.38
In the future most jobs will require a knowledge of science.	2.46	.73	.34
People who understand science are better off in our society.	1.97	.84	.39
It is important to know science in order to get a good job.	1.92	.86	.40
Science is a very good field for creative people to enter.	2.56	.69	.27
In my future career I would like to use the science I learned at school.	2.09	.79	.43
People who work with modern inventions such as computers have more interesting jobs.	1.78	.86	.26
I would like to become a science teacher when I leave school.	1.19	.46	.12
Scientists are responsible for the way in which their discoveries are applied.	2.28	.75	.10

Grade 9: Overall Item Analyses

Means, standard deviations, alpha reliability coefficients, and correlations among the subscale scores are summarized in Table 23.

The subscale means range from 15.42 (Science as a School Subject) to 34.95 (Importance of Science). However, the comparison of mean scores is meaningful only if they are converted to the same metric. The four subscale mean scores represent 74%, 78%, 68%, and 73% of the respective total possible scores. Although students have a positive attitude toward the importance of science (78%), they are some what less enthusiastic about science as a school subject (73%) or careers in science (68%). The total mean score is 85.23, which represents 73% of the total possible score. In general, it can be concluded that grade 9 students hold favourable attitudes toward school and science.

The alpha reliability coefficients of the subscale scores are acceptable, ranging from .62 (Careers in Science) to .74 (Attitude Toward School). However, items in the Attitude Toward School subscale are more internally consistent than items in the Careers in Science subscale. The overall reliability of .84 is high for this type of self-report questionnaire.

The intercorrelations, which range from .25 to .45, indicate that the three science subscales have more in common with each other than each has in common with the Attitude Toward School subscale.

Table 23

Grade 9: Means, Standard Deviations, Alpha Reliability Coefficients, and Correlations Among the Subscales

Subscale	1	2	3	4	Total Score
1. Attitude Toward School		.34	.25	.36	.68
2. Importance of Science			.43	.45	.81
3. Careers in Science				.38	.68
4. Science as a School Subject					.73
Maximum Possible Score	24.00	45.00	27.00	21.00	117.00
Mean	16.46	34.95	18.40	15.42	85.23
Standard Deviation	3.94	4.89	3.44	3.33	11.39
Alpha Reliability	.74	.73	.62	.66	.84

Grade 9: Factor Analysis of the Attitude Scale

Table 24 includes the rotated factor loadings of the 40 attitude items in the four subscales.

The negatively worded items in the Attitude Toward School subscale emerge on the first factor, and the positively worded statements about school and education load on the eighth and ninth factors. These three factors collectively represent the Attitude Toward School subscale.

Items on importance of science load on the second, third, and sixth factors, while items on careers in science emerge on the fourth and seventh factors. The item on responsibility of scientists for the application of their discoveries emerges on the tenth factor, along with the item on proper instruction of science.

Three of the seven items on science as a school subject load on the fifth factor. They all relate to negative aspects of studying science, such as the difficulty of the subject and the number of facts that must be mastered. The item about handling apparatus in science does not have loadings greater than absolute .40 on any of the eleven factors.

Overall, the structure of the attitude scale is more complex than the four subscales. The prior classification of items into the four subscales is not entirely supported by the results of the factor analysis. Item responses align themselves empirically in terms of somewhat different themes than those determined conceptually by the authors.

Table 24

Grade 9: Rotated Factor Loadings and Communalities of Items in the Attitude Scale[a]

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	h^2
Science is useful for solving the problems of everyday life.			.67									.56
I find school challenging.								.67				.56
Science has ruined the environment.		-.48										.43
Working in a science laboratory would be an interesting way to earn a living.							.54					.47
Science is very important for a country's development.		.53										.44
School is not very enjoyable.	.74											.62
Money spent on science is well worth spending.		.58										.47
In the future most jobs will require a knowledge of science.				.68								.57
I enjoy everything about school.									.61			.56
Much of the anxiety in modern society is due to science.						.59						.48
People who understand science are better off in our society.				.56								.43
Public money spent on science in the last few years has been used wisely.										.69		.59

continued . . .

Table 24, Continued

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	h^2
It is important to know science in order to get a good job.				.67								.52
I am bored most of the time in school.	.79											.65
Scientific inventions improve our standard of living.		.54										.36
The government should spend more money on scientific research.		.47										.39
Scientific inventions have made the world too complex.		-.47				.42						.52
Science is a very good field for creative people to enter.												.43
There are many school subjects I don't like.	.65											.50
Scientific inventions have increased tensions between people.						.64						.45
In my future career I would like to use the science I learned at school.												.50
Science will help to make the world a better place in the future.		.65										.58
The most enjoyable part of my life is the time I spend at school.									.76			.63
Scientific discoveries do more harm than good.		-.53										.46

continued

Table 24, Continued

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	h^2
People who work with modern inventions such as computers have more interesting jobs.												.56
I want as much education as I can get.								.50				.52
Science and technology are the causes of many of the world's problems.						.62						.47
I generally dislike my schoolwork.	.71											.60
I want to learn more about the world we live in.			.47					.46				.49
I would like to become a science teacher when I leave school.							.71					.58
Scientists are responsible for the way in which their discoveries are applied.										.62		.46
In the next five years, things in Canada will probably get worse.						.49						.43
If properly taught, almost all students could learn science.										.52		.38
Science is an enjoyable school subject.			.44				.43					.66
The science taught at school is interesting.			.46									.57
Science is a difficult subject.					.76							.64

continued . . .

Table 24, Continued

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	h^2
Science is difficult when it involves calculations.					.70							.59
Science is difficult when it involves handling apparatus.												.44
There are too many facts to learn in science.					.59							.54
Science is relevant to everyday life.			.62									.51

[a] Factor loadings less than absolute .40 are not reported, and h^2 indicates the communality of an item.

Grade 9: Summary

One fifth of the grade 9 students report that their marks in science are better than marks in other school subjects; about one third make a similar judgment about their mathematics marks. A sizeable proportion of students like science and mathematics better than other school subjects. Almost every grade 9 student has a calculator for use at school and at home, and about half of the students have a computer at home. Although 85% of the students have access to a computer at school, 80% of them have never used it. Almost all students say that they intend to finish grade 12, and although 58% plan to continue their education after high school, about one third remain undecided. A large number of students spend some time doing homework each week.

Grade 9 students use a textbook during science classes. At the start of each science class, the teacher reminds students about the work covered in previous classes and work to be covered in the current class; at the end of the class, the topics covered are summarized. Students are rarely allowed to choose their own topics to study, although sometimes the teacher uses their ideas and suggestions in planning science lessons. Teachers perform experiments to explain scientific ideas, and students do laboratory work as part of science classes, often or sometimes in small groups, guided by the teacher or written instructions. Students do not make up their own problems, but work on those given by the teacher. Students are often tested on what they have learned in science.

Although most students disagree with the idea that they enjoy everything about school, they do find school challenging and desire to get as much education as possible. In general, more girls than boys manifest positive attitudes toward school. A large number of students agree that science is important to them and to the country as a whole. Students tend to disagree that science has made the world more complex and that science has ruined the environment. Very few of the students would like to become science teachers but would consider careers in other science-related areas.

About half of the students agree that science is an enjoyable and interesting subject, but that it involves too many facts. A majority of the students agree that science could be learned by almost any student if properly instructed.

Item-subscale correlations from the item analysis point to item validities for the purpose of discriminating between students who hold different attitudes and opinions. The alpha reliability coefficients for the subscales and the total scale are in the acceptable range. The factor analysis of the 40 attitude items in the four subscales reveals a more complex structure than originally conceptualized.

Senior Division: Mathematics, Computing Aids, and Homework

Response frequencies of items about school marks in science and mathematics, preference for science and mathematics, the use of calculators and computers, future educational plans, and science subjects taken in the past are presented in Table 25.

Senior division students generally report better marks in mathematics than in science, compared to other subjects. One quarter of the students judge their science marks to be "better than other subjects;" the corresponding percentage for marks in mathematics is 38%. In addition, about half of the students (53%) feel that their science marks are about average, compared to 37% who perceive their mathematics grades as average. There are significant gender differences for both science and mathematics, with more boys than girls reporting better marks in both subjects.

A majority of the senior division students say they like science (85%) and mathematics (72%) more than or the same as other school subjects. More boys than girls indicate that they prefer science and mathematics to other subjects.

Students are about equally divided on the question asking about one or more science courses: 48% are taking only one science course, while 52% are taking more than one science course.

Almost all of the students have a calculator for use at school (95%) and at home (97%). Although most students (91%) also have access to computers at school, 74% report that they never use one. This finding is difficult to explain, since 63% of these students indicate that they are enrolled in a computer science course. About half of the students (52%) also indicate that they have a computer at home. More girls than boys say that they never use a computer. Boys are more likely than girls to report having a computer at home and being currently enrolled in a computer science course.

A majority of the students (88%) are enrolled at the advanced level, and 74% plan to obtain at least three years of education after high school. Six out of ten students expect to include science as part of their future studies; however, there is no trend toward a specific course or academic discipline.

Slightly more than half of the students (52%) say they took a general science course in the 1983-84 academic school year. For 1984-85, the proportion of students who say they took general science drops, and there is a corresponding increase in the number of students who say they took biology and physics. Biology, chemistry, and physics remain popular science subjects with senior division students during the 1985-86 and 1986-87 academic years.

Virtually every student reports doing homework each week, spending at least up to two hours. About one fifth of the students spend 10 or more hours on homework per week. Almost all the students (93%) spend some time on science homework; 12% spend more than five hours per week on homework in science.

Table 25

Senior Division: Response Frequencies of Items about School Marks, Preference for Science and Mathematics, Use of Calculators and Computers, Future Educational Plans, and Homework

Item	n	%
Science Marks		
-better than other subjects	333	26
-about average	664	53
-worse than most	264	21
Math Marks		
-better than other subjects	484	38
-about average	472	37
-worse than most	311	24
Like Science		
-more than most other subjects	499	39
-about the same as other subjects	582	46
-less than most other subjects	186	15
Like Math		
-more than most subjects	393	31
-about the same	515	41
-less than most subjects	358	28
I Am Taking		
-only one science course	612	48
-more than one science course	655	52
Calculator For Use At School		
-yes	1,205	95
-no	61	5
Calculator For Use At Home		
-yes	1,231	97
-no	35	3
Computer At School		
-yes	1,145	91
-no	116	9
Hours Use Computer		
-never	935	74
-up to 2 hours	166	13
-3-5 hours	110	9
-6-10 hours	45	3
-More than 10 hours	7	1

continued . . .

Table 25, Continued

Item	n	%
Have Computer At Home		
-yes	650	52
-no	612	48
Taking Computer Science		
-yes	796	63
-no	468	37
Level Of Courses		
-advanced	1,119	88
-general	145	11
-basic	1	1
Years Of Further Education		
-not continuing	17	1
-1 - 2 years	106	8
-3 - 4 years	430	34
-4+ years	505	40
-not decided	206	16
Expect To Include Science		
-I expect to include science	782	62
-I do not expect to include science	243	19
-I'm not continuing my education	14	1
-I have not decided	228	18
Course You Expect To Take		
-I don't expect to continue	11	1
-agriculture, fishing, forestry	22	2
-architecture, building, surveying	35	3
-art, design, music	48	4
-business, commercial studies	205	16
-education	50	4
-engineering, technology	173	14
-general studies	65	5
-health science	263	21
-social science	70	5
-pure/applied science	61	5
-other	98	8
-not decided	149	12
Science Subjects (1983-84)		
-general science	656	52
-environmental science	67	5
-biology	266	21
-chemistry	25	2
-physics	133	10

continued . . .

Table 25, Continued

Item	n	%
Science Subjects (1984-85)		
-general science	267	21
-environmental science	79	6
-biology	508	40
-chemistry	59	5
-physics	461	36
Science Subjects (1985-86)		
-general science	63	5
-environmental science	71	6
-biology	578	46
-chemistry	288	23
-physics	466	37
Science Subjects (1986-87)		
-general science	6	1
-environmental science	28	2
-biology	546	43
-chemistry	708	56
-physics	685	54
Hours Spent On Homework		
-I never have homework	35	3
-up to 2 hours	255	20
-3 - 5 hours	351	28
-6 - 10 hours	361	28
-11 - 20 hours	214	17
-more than 20 hours	49	4
Hours Spent On Science		
-I never have homework	75	6
-up to 2 hours	646	51
-3 - 5 hours	386	30
-6 - 10 hours	129	10
-over 10 hours	25	2

Senior Division: Activities During Science Learning

Table 26 shows the response frequencies of items related to activities which take place during science lessons.

Almost all of the students indicate that they use a textbook "sometimes" or "often" (95%) during science classes. Half of the students say that they "never" use books other than textbooks. Most of the students report that "sometimes" or "often" the teacher reminds them about the work covered during previous classes (88%), explains the work to be covered during the current class (86%), and at the end of the class gives a summary of what has been taught (72%). Many students also agree that "sometimes" or "often" their science teachers make classes interesting for them (87%), explain the relevance of science to their lives (84%), and discuss possible careers in science (54%).

About three out of four students (72%) indicate that they "never" choose science topics to be covered in class; 35% of the students agree that "sometimes" the teacher uses their ideas and suggestions when planning science classes.

Almost all of the students report that "sometimes" or "often" the teacher performs demonstrations to explain scientific ideas (95%); that they copy the teacher's notes from the blackboard (93%); that they are divided into small groups to do laboratory work (94%); and that they write reports of these experiments as part of their homework in science (90%). A majority of students report that in lab work the teacher "often" gives instructions about what to do (72%), and also uses a book or a manual of written instructions (61%). Three out of four students note that they "never" make up their own problems to be solved independently or with the help of the teacher, but that "sometimes" or "often" the teacher gives them problems to solve on their own (77%).

A sizeable number of the students (69%) remark that they "never" do field work outside the science classroom. The teacher is "sometimes" (39%) or "often" (53%) available to help students if they experience difficulties. Students "sometimes" or "often" use calculators during science classes (87%), and have tests in what they have learned in science (99%).

There are significant gender differences on five of the 24 activities listed in Table 26. More girls than boys report that the teacher helps students with difficulties; that they do laboratory work as part of their science classes; that they work in small groups; and that the teacher gives instructions about what to do. On the other hand, boys are significantly more likely than girls to indicate the use of calculators during science classes.

Table 26

Senior Division: Response Frequencies of Items about Activities During Science Classes

Item Statement	Often		Sometimes		Never	
	n	%	n	%	n	%
We use a textbook during science classes.	633	50	566	45	56	4
We use books other than textbooks for learning science.	88	7	524	41	641	51
At the start of each science class the teacher reminds us about the work we covered during previous classes.	470	37	648	51	137	11
At the start of each science class the teacher explains the work we have to cover during the class.	479	38	614	48	160	13
At the end of each science class the teacher gives a summary of what was taught in the class.	207	16	704	56	338	28
We are allowed to make our own choice of science topics to study.	121	10	216	17	912	72
The teacher uses our ideas and suggestions when planning science classes.	47	4	441	35	758	60
The teacher does demonstrations to help explain scientific ideas.	671	53	528	42	52	4
The teacher makes science classes interesting for us.	487	38	624	49	136	11
During science classes we copy the teacher's notes from the blackboard into our own books.	726	57	462	36	55	4
For science homework we write up reports of our laboratory and practical work.	531	42	607	48	113	9

continued . . .

Table 26, Continued

Item Statement	Often		Sometimes		Never	
	n	%	n	%	n	%
The teacher explains how the science we learn is relevant to our own lives.	372	29	691	55	188	15
The teacher discusses possible careers in science with us.	119	9	609	48	521	41
We have tests on what we have learned in science.	1,104	87	139	11	7	1
The science teacher helps students who have difficulties with learning science.	673	53	495	39	74	6
We use calculators during science classes.	699	55	405	32	146	12
We do field work outside the classroom as part of our science classes.	17	1	352	28	878	69
We do laboratory work as part of our science classes.	622	49	593	47	33	3
The science class breaks into small groups of students to do laboratory work.	822	65	366	29	61	5
When we do laboratory work the teacher gives us instructions about what to do.	917	72	282	22	48	4
When we do laboratory or field work we use a book or other written instructions to show us how to do it.	769	61	364	29	113	9
In our laboratory or field work we make up our own problems and then the teacher helps us to plan experiments to solve them.	55	4	281	22	909	72

continued . . .

Table 26, Continued

Item Statement	Often		Sometimes		Never	
	n	%	n	%	n	%
When we do laboratory or field work the teacher gives us problems to solve and then leaves us to work out our own methods and solutions.	337	27	633	50	278	22
In our laboratory or field work we make up our own problems and work out our own methods to investigate the problems.	45	4	267	21	936	74

Senior Division: Attitude Toward School Subscale

This, and the following sections of the senior division findings deal with the second section of the senior division survey -- the 56 attitudinal items which are divided into six subscales: Attitude Toward School, Importance of Science, Attitude Toward Biology, Attitude Toward Chemistry, Attitude Toward Physics, and Careers in Science.

Table 27 presents the response frequencies for the Attitude Toward School subscale. The summary statistics for this scale are given in Table 28.

Approximately three out of four senior division students agree that they find school challenging (74%) and that they would like to get as much education as possible (79%). About half of the students disagree with statements that school is not very enjoyable (56%), that school is boring (49%), and that they generally dislike their schoolwork (49%). However, two thirds of the students disagree that they enjoy everything about school (65%) and the time they spend at school is the most enjoyable part of their lives (64%). There is an equal split among students on the statement: "There are many school subjects I don't like," with 44% agreeing and 43% disagreeing.

The item means are fairly high, indicating that the students generally hold a favorable attitude towards school. The item-subscale correlations range from .28 to .68, showing that the items discriminate among students whose attitudes towards school differ in degree of favorableness.

There are significant gender differences on seven of the eight items in this subscale. Boys and girls do not differ significantly in their responses to the statement: "The most enjoyable part of my life is the time I spend at school." For the other seven statements, more girls than boys tend to express positive attitudes toward school.

Table 27

Senior Division: Response Frequencies of Items in the Attitude Toward School Subscale

Item Statement	Strongly Agree/ Agree n	Strongly Agree/ Agree %	Uncertain n	Uncertain %	Strongly Disagree/ Disagree n	Strongly Disagree/ Disagree %
I find school challenging.	939	74	157	12	172	14
School is not very enjoyable.	343	27	210	17	715	56
I enjoy everything about school.	206	16	243	19	819	65
I am bored most of the time in school.	455	36	186	15	627	49
There are many school subjects I don't like.	561	44	157	12	550	43
The most enjoyable part of my life is the time I spend at school.	229	18	229	18	810	64
I want as much education as I can get.	1,001	79	198	16	69	5
I generally dislike my schoolwork.	408	32	241	19	619	49

Table 28

Senior Division: Summary Statistics for Items in the Attitude Towards School Subscale

Item Statement	M	SD	Item-Subscale Correlation
I find school challenging.	3.73	.94	.33
School is not very enjoyable.	3.33	1.11	.68
I enjoy everything about school.	2.38	.97	.54
I am bored most of the time in school.	3.10	1.15	.67
There are many school subjects I don't like.	2.93	1.13	.49
The most enjoyable part of my life is the time I spend at school.	2.34	1.08	.46
I want as much education as I can get.	4.09	.87	.28
I generally dislike my schoolwork.	3.14	1.07	.64

Senior Division: Importance of Science Subscale

Tables 29 and 30 summarize the analyses of items in the Importance of Science subscale.

A large majority of students agree that science is very important for a country's development (92%); that scientific inventions improve the standard of living (88%); and that they want to learn more about the world they live in (86%). Almost three quarters of the students feel that science is useful for solving everyday problems (73%) and that money allocated to science is well worth spending (72%). Two thirds of the students agree that science will help to make the world of the future a better place. This generally positive view of science tends to be supported by the 56% of students who disagree that science has ruined the environment, and the 55% who do not feel that science has made the world overly complex.

The students tend to be uncertain about whether science has caused numerous world problems (33%), has increased societal anxiety (45%), or has increased tensions between people (41%). Approximately six out of ten students are not sure if public money spent on science in the past has been used wisely, although 52% feel that the government should spend more money on research.

The item means all fall toward the positive end of the scale; they range from 3.07 to 4.36, indicating that the senior division students view science as a very important discipline. The item-subscale correlations range from .23 ("I want to learn more about the world we live in") to .55 ("Scientific discoveries do more harm than good"). The magnitude of these correlations indicates a fairly high relationship with the total subscale score.

There are a few items on which boys and girls respond differently. Girls are more likely than boys to be uncertain about whether money spent on science has been used wisely; about whether scientific inventions have made the world more complex and have increased tensions between people; and about whether science and technology are the causes of the world's problems.

Table 29

Senior Division: Response Frequencies of Items in the Importance of Science Subscale

Item Statement	Strongly Agree/ Agree n	%	Uncertain n	%	Strongly Disagree/ Disagree n	%
Science is useful for solving the problems of everyday life.	926	73	211	17	131	10
Science has ruined the environment.	175	14	378	30	715	56
Science is very important for a country's development.	1,162	92	88	7	18	1
Money spent on science is well worth spending.	915	72	293	23	60	5
Much of the anxiety in modern society is due to science.	276	22	578	45	414	33
Public money spent on science in the last few years has been used wisely.	319	25	781	62	168	13
Scientific inventions improve our standard of living.	1,115	88	125	10	28	2
The government should spend more money on scientific research.	659	52	479	38	130	10
Scientific inventions have made the world too complex.	247	20	320	25	701	55
Scientific inventions have increased tensions between people.	467	37	525	41	276	22
Science will help to make the world a better place in the future.	834	66	360	28	74	6

continued . . .

Table 29, Continued

Item Statement	Strongly Agree/ Agree n	%	Uncertain n	%	Strongly Disagree/ Disagree n	%
Scientific discoveries do more harm than good.	90	7	417	33	761	60
Science and technology are the causes of many of the world's problems.	377	30	420	33	471	37
I want to learn more about the world we live in.	1,090	86	135	11	43	3

Table 30

Senior Division: Summary Statistics for Items in the Importance of Science Subscale

Item Statement	M	SD	Item-Subscale Correlation
Science is useful for solving the problems of everyday life.	3.80	.90	.30
Science has ruined the environment.	3.57	1.03	.40
Science is very important for a country's development.	4.36	.70	.37
Money spent on science is well worth spending.	3.87	.80	.50
Much of the anxiety in modern society is due to science.	3.13	.84	.28
Public money spent on science in the last few years has been used wisely.	3.13	.75	.26
Scientific inventions improve our standard of living.	4.17	.70	.41
The government should spend more money on scientific research.	3.59	.93	.42
Scientific inventions have made the world too complex.	3.40	.95	.41
Scientific inventions have increased tensions between people.	2.80	.93	.33

continued . . .

Table 30, Continued

Item Statement	M	SD	Item-Subscale Correlation
Science will help to make the world a better place in the future.	3.74	.83	.53
Scientific discoveries do more harm than good.	3.63	.83	.55
Science and technology are the causes of many of the world's problems.	3.07	1.00	.46
I want to learn more about the world we live in.	4.10	.70	.23

Senior Division: Attitude Toward Biology Subscale

Table 31 includes the response frequencies for the items in the Attitude Toward Biology subscale. Summary statistics for this subscale are given in Table 32.

About three out of four students feel that almost all students can learn biology if properly taught, that biology is relevant to everyday life, and that handling apparatus during biology classes does not make the subject difficult. Approximately two thirds of the students agree that biology is enjoyable and interesting. The students tend not to feel that biology is a difficult subject generally (53%), that calculations make it difficult (56%), or that there are too many facts to be learned in biology (46%).

The magnitude of the item means indicates that the students hold positive attitudes toward biology. The item-subscale correlations range from .24 to .63, showing generally acceptable correlations with the total score.

There are significant gender differences on all items except: "If properly taught, almost all students could learn biology." For the other seven statements, more girls than boys respond positively, suggesting that biology is a particularly popular subject with female students.

Table 31

Senior Division: Response Frequencies of Items in the Attitude Toward Biology Subscale

Item Statement	Strongly Agree/ Agree n	Strongly Agree/ Agree %	Uncertain n	Uncertain %	Strongly Disagree/ Disagree n	Strongly Disagree/ Disagree %
If properly taught, almost all students could learn biology.	965	76	139	11	164	13
Biology is an enjoyable school subject.	843	67	202	16	223	17
The biology taught at school is interesting.	817	64	225	18	226	18
Biology is a difficult subject.	398	31	199	16	671	53
Biology is difficult when it involves calculations.	227	18	325	26	616	56
Biology is difficult when it involves handling apparatus.	113	9	199	16	956	75
There are too many facts to learn in biology.	450	35	236	19	582	46
Biology is relevant to everyday life.	908	72	224	17	136	11

Table 32

Senior Division: Summary Statistics for Items in the Attitude Toward Biology Subscale

Item Statement	M	SD	Item-Subscale Correlation
If properly taught, almost all students could learn biology.	3.81	.96	.29
Biology is an enjoyable school subject.	3.61	1.09	.63
The biology taught at school is interesting.	3.57	1.03	.57
Biology is a difficult subject.	3.26	1.11	.43
Biology is difficult when it involves calculations.	3.48	1.00	.24
Biology is difficult when it involves handling apparatus.	3.83	.86	.38
There are too many facts to learn in biology.	3.08	1.13	.48
Biology is relevant to everyday life.	3.77	.93	.39

Senior Division: Attitude Toward Chemistry Subscale

Response frequencies for items in the Attitude Toward Chemistry subscale are given in Table 33, followed by item statistics in Table 34.

Two thirds of the respondents agree that almost all students could learn chemistry if properly taught; however, only half of the students find chemistry enjoyable, interesting, and relevant to everyday life. Although 57% of the students do not feel that handling apparatus makes chemistry difficult, 44% view it as a difficult subject generally, 37% feel chemistry is difficult when it involves calculations, and 32% agree that there are too many facts to learn in chemistry.

The magnitude of the item mean scores reflects to some extent this less positive view of chemistry. The item-subscale correlations (.24 to .64) are within the acceptable range.

There are no significant gender differences on any of the eight items in this subscale. Boys and girls respond similiarly to all statements regarding their attitudes toward chemistry.

Table 33

Senior Division: Response Frequencies of Items in the Attitude Towards Chemistry Subscale

Item Statement	Strongly Agree/ Agree n	Strongly Agree/ Agree %	Uncertain n	Uncertain %	Strongly Disagree/ Disagree n	Strongly Disagree/ Disagree %
If properly taught, almost all students could learn chemistry.	845	67	203	16	220	17
Chemistry is an enjoyable school subject.	646	51	397	31	225	18
The chemistry taught at school is interesting.	635	50	437	34	196	15
Chemistry is a difficult subject.	563	44	347	27	358	28
Chemistry is difficult when it involves calculations.	474	37	341	27	453	36
Chemistry is difficult when it involves handling apparatus.	186	15	361	28	721	57
There are too many facts to learn in chemistry.	400	32	419	33	449	35
Chemistry is relevant to everyday life.	666	52	401	32	201	16

Table 34

Senior Division: Summary Statistics for Items in the Attitude Toward Chemistry Subscale

Item Statement	M	SD	Item-Subscale Correlation
If properly taught, almost all students could learn chemistry.	3.63	1.02	.24
Chemistry is an enjoyable school subject.	3.89	.99	.64
The chemistry taught at school is interesting.	3.39	.95	.56
Chemistry is a difficult subject.	2.75	1.08	.55
Chemistry is difficult when it involves calculations.	2.95	1.14	.45
Chemistry is difficult when it involves handling apparatus.	3.52	.94	.35
There are too many facts to learn in chemistry.	3.01	1.04	.49
Chemistry is relevant to everyday life.	3.43	.92	.36

Senior Division: Attitude Toward Physics Subscale

Tables 35 and 36 summarize response frequencies and item statistics for the Attitude Toward Physics subscale.

A majority of the students agree that almost all students could learn physics if properly taught (62%); that it is relevant to everyday life (64%); but that it is a difficult subject (62%). Students are much more likely to find physics difficult when it involves calculations (55%) than when it involves handling apparatus (17%). Forty-two percent agree that there are too many facts to learn in physics. However, about half of the students agree that physics is an enjoyable and interesting subject.

The item means range from 2.42 ("Physics is a difficult subject") to 3.60 ("Physics is relevant to everyday life"). Except for the first item in the subscale (.25), the item-subscale correlations are moderate-to-high, ranging from .39 to .68. These correlations indicate that the items discriminate between students who hold more favorable attitudes and those who hold less favorable attitudes towards physics.

There are significant gender differences in the responses to all items except: "There are too many facts to learn in physics." For the other seven items, significantly more boys than girls manifest a positive attitude towards physics.

Table 35

Senior Division: Response Frequencies of Items in the Attitude Toward Physics Subscale

Item Statement	Strongly Agree/ Agree		Uncertain		Strongly Disagree/ Disagree	
	n	%	n	%	n	%
If properly taught, almost all students could learn physics.	790	62	201	16	277	22
Physics is an enjoyable school subject.	624	49	266	21	378	30
The physics taught at school is interesting.	662	52	273	22	333	26
Physics is a difficult subject.	781	62	181	14	306	24
Physics is difficult when it involves calculations.	692	55	185	14	391	31
Physics is difficult when it involves handling apparatus.	218	17	228	18	822	65
There are too many facts to learn in physics.	540	42	262	21	466	37
Physics is relevant to everyday life.	817	64	258	20	193	15

Table 36

Senior Division: Summary Statistics for Items in the Attitude Toward Physics Subscale

Item Statement	M	SD	Item-Subscale Correlation
If properly taught, almost all students could learn physics.	3.51	1.11	.25
Physics is an enjoyable school subject.	3.20	1.17	.68
The physics taught at school is interesting.	3.28	1.13	.58
Physics is a difficult subject.	2.42	1.19	.58
Physics is difficult when it involves calculations.	2.59	1.27	.51
Physics is difficult when it involves handling apparatus.	3.58	1.02	.38
There are too many facts to learn in physics.	2.86	1.16	.52
Physics is relevant to everyday life.	3.60	1.00	.39

Senior Division: Careers in Science Subscale

Tables 37 and 38 include response frequencies and item statistics for the Careers in Science subscale.

A majority of the students agree that knowledge of science is an important requirement for future jobs (68%); that science is a good career field for creative people (67%); and that they would like to enter careers where they could use the science they learned at school (60%). About half of the students agree that people who understand science are better off in our society (48%), and that working in a laboratory would be an interesting job (53%). However, only 35% of the students feel that science is important for getting a good job. Only 4% of the students would like to be science teachers, while 19% feel that working in jobs involving such modern inventions as computers could be interesting. Forty percent of the students believe that scientists are responsible for the application of their discoveries.

The item means range from 1.75 ("I would like to become a science teacher when I leave school") to 3.81 ("In the future most jobs will require a knowledge of science"). The item: "Scientists are responsible for the way in which their discoveries are applied," with an item-subscale correlation of .03, bears no relationship to the total score on this subscale. The other item-subscale correlations are acceptable, ranging from .28 to .50.

There are no significant gender differences on items relating to the importance of science for getting a good job and the usefulness of science in a future career. A significantly higher proportion of girls than boys agree that working in a science laboratory would be interesting, but disagree with the idea that they would like to become science teachers. Boys are more likely than girls to agree that most future jobs will require a knowledge of science; that people who understand science are better off in our society; that science is a good field for creative people; and that jobs involved with modern technology are interesting. Significantly more boys than girls disagree that scientists are responsible for the ways in which their discoveries are applied, and significantly more girls than boys say they are uncertain about this statement.

Table 37

Senior Division: Response Frequencies of Items in the Careers in Science Subscale

Item Statement	Strongly Agree/ Agree n	%	Uncertain n	%	Strongly Disagree/ Disagree n	%
Working in a science laboratory would be an interesting way to earn a living.	668	53	288	22	312	25
In the future most jobs will require a knowledge of science.	866	68	297	23	105	8
People who understand science are better off in our society.	611	48	345	27	312	25
It is important to know science in order to get a good job.	445	35	308	24	515	41
Science is a very good field for creative people to enter.	845	67	236	18	187	15
In my future career I would like to use the science I learned at school.	759	60	293	23	216	17
People who work with modern inventions such as computers have more interesting jobs.	243	19	314	25	711	56
I would like to become a science teacher when I leave school.	44	4	182	14	1,042	82
Scientists are responsible for the way in which their discoveries are applied.	502	40	380	30	386	30

Table 38

Senior Division: Summary Statistics for Items in the Careers in Science Subscale

Item Statement	M	SD	Item-Subscale Correlation
Working in a science laboratory would be an interesting way to earn a living.	3.34	1.13	.41
In the future most jobs will require a knowledge of science.	3.81	.88	.46
People who understand science are better off in our society.	3.31	.99	.46
It is important to know science in order to get a good job.	2.95	1.04	.49
Science is a very good field for creative people to enter.	3.64	.96	.38
In my future career I would like to use the science I learned at school.	3.58	1.04	.50
People who work with modern inventions such as computers have more interesting jobs.	2.56	1.01	.37
I would like to become a science teacher when I leave school.	1.75	.86	.28
Scientists are responsible for the way in which their discoveries are applied.	3.09	1.07	.03

Senior Division: Overall Item Analyses

Means, standard deviations, alpha reliability coefficients, and correlations among the six subscales are presented in Table 39.

The subscale mean scores were converted into percentages of the maximum possible scores. These converted scores range from 62% (Careers in Science) to 72% (Importance of Science). The total mean score (182.96) represents 66% of the maximum possible score for all 56 items. In general, it can be concluded that senior division students have positive attitudes toward school, toward biology, chemistry, and physics as school subjects, and toward careers in science. In addition, they consider science to be an important discipline which influences the life of every individual.

The alpha reliability coefficients range from .70 (Careers in Science) to .80 (Attitude Toward School). Reliability coefficients in this range are quite acceptable, indicating that the various subscales are internally consistent.

The intercorrelations range from .19 to .52. The lowest correlation is between Attitude Toward Biology and Attitude Toward Physics. The highest correlation is between Attitude Toward Chemistry and Attitude Toward Physics.

Table 39

Senior Division: Means, Standard Deviations, Alpha Reliability Coefficients, and Correlations Among the Subscales

Subscale	1	2	3	4	5	6	Total Score
1. Attitude Towards Schools		.22	.29	.24	.21	.27	.58
2. Importance of Science			.29	.31	.32	.44	.69
3. Attitude Towards Biology				.32	.19	.30	.60
4. Attitudes Towards Chemistry					.52	.29	.68
5. Attitudes Towards Physics						.31	.67
6. Careers in Science							.66
Maximum Possible Score	40.00	70.00	40.00	40.00	40.00	45.00	275.00
Mean	25.05	50.35	28.41	26.07	25.04	28.03	182.96
Standard Deviation	5.40	6.08	4.80	4.91	5.71	4.88	20.54
Alpha Reliability	.80	.78	.73	.75	.78	.70	.89

Senior Division: Factor Analysis of the Attitude Scale

Rotated factor loadings of the 56 items on the six subscales are given in Table 40.

Fourteen factors emerge from this analysis. Except for the item "I want to get as much education as I can get," all items in the Attitude Toward School subscale load on the first factor. The above item loads on the fourteenth factor with another item: "I want to learn more about the world we live in." These two items seem to be more logically related to each other than to items in the Attitude Toward School or Importance of Science subscales, where they were originally classified. The desire to get more education may be similar to the desire to learn more about the world.

Some of the items which were separately classified into the Attitude Toward Biology, Attitude Toward Chemistry, and Attitude Toward Physics subscales emerge on the second factor. The common theme of these items, whether the area is biology, chemistry, or physics, is the difficulty of the subject when it involves calculations. The three items on handling apparatus load on the ninth factor, regardless of whether biology, chemistry, or physics is being considered.

Most of the positively worded items in the Importance of Science subscale load on the third factor; the negatively worded items in this subscale load on the fourth factor. The first item in this subscale, "Science is useful for solving problems of everyday life," loads on the eleventh factor, along with items on the relevance of biology, chemistry, and physics to everyday life.

The item "In the next five years things in Canada will probably get worse," has moderate loadings on the fourth factor, defined by the negative items in the Importance of Science subscale. This particular item was omitted from the item analyses since it could not logically be classified into any of the six subscales.

The fifth factor is defined by some of the items on the Attitude Toward Biology subscale. Similarly, the sixth and the tenth factors are defined by some of the items in the Attitude Toward Physics and Attitude Toward Chemistry subscales. The three items related to students being able to learn biology, chemistry, physics if properly instructed load on the eighth factor.

The seventh and the thirteenth factors relate to items in the Careers in Science subscale. Items on laboratory jobs, science as a field for creative people, and jobs involving modern technology emerge on the same factor. Items relating to the importance of science for future jobs load on a different factor. Items on becoming a science teacher and responsibility of scientists for their discoveries do not load significantly on any of the 14 factors.

Items on "too many facts" to be learned in biology, chemistry, and physics load on the same factor. These items were originally classified into the Attitude Toward Biology, Attitude Toward Chemistry, and Attitude Toward Physics subscales.

The results of the factor analysis indicate a more complex structure of the 56 attitude items than their original classification into the six subscales. This is true especially for items in the Science as a School Subject subscale. Items are more strongly related on the basis of underlying concepts: e.g., relevance to everyday life, quality of instruction, subject content, difficulty of the subject in general, and difficulty of the subject when it involves handling calculations or apparatus.

Table 40

Senior Division: Rotated Factor Loadings and Communalities of Items in the Attitudinal Scale[a]

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	h^2
Science is useful for solving the problems of everyday life.											.43				.46
I find school challenging.	.44														.36
Science has ruined the environment.				.52											.37
Working in a science laboratory would be an interesting way to earn a living.													.51		.54
Science is very important for a country's development.			.70												.53
School is not very enjoyable.	−.80														.68
Money spent on science is well worth spending.			.65												.54
In the future most jobs will require a knowledge of science.							.68								.57
I enjoy everything about school.	.67														.53
Much of the anxiety in modern society is due to science.				.58											.45

continued . . .

Table 40, Continued

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	h^2
People who understand science are better off in our society.							.64								.55
Public money spent on science in the last few years has been used wisely.															.43
It is important to know science in order to get a good job.							.73								.63
I am bored most of the time in school.	-.79														.65
Scientific inventions improve our standard of living.			.66												.51
The government should spend more money on scientific research.			.56												.45
Scientific inventions have made the world too complex.				.54											.43
Science is a very good field for creative people to enter.													.51		.41
There are many school subjects I don't like.	-.60														.47

continued . . .

Table 40, Continued

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	h^2
Scientific inventions have increased tensions between people.				.70											.54
In my future career I would like to use the science I learned at school.							.51								.57
Science will help to make the world a better place in the future.			.51												.50
The most enjoyable part of my life is the time I spend at school.	.59														.46
Scientific discoveries do more harm than good.				.58											.53
People who work with modern inventions such as computers have more interesting jobs.													.67		.55
I want as much education as I can get.														.60	.56
Science and technology are the causes of many of the world's problems.				.72											.56
I generally dislike my schoolwork.	−.73														.63

continued . . .

Table 40, Continued

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	h^2
I want to learn more about the world we live in.														.63	.55
I would like to become a science teacher when I leave school.															.34
Scientists are responsible for the way in which their discoveries are applied.															.38
In the next five years, things in Canada will probably get worse.				.42											.29
If properly taught, almost all students could learn biology.								.82							.78
If properly taught, almost all students could learn chemistry.								.90							.87
If properly taught, almost all students could learn physics.								.87							.82
Biology is an enjoyable school subject.					.81										.75
Chemistry is an enjoyable school subject.										.81					.82
Physics is an enjoyable school subject.						.80									.79

continued . . .

Table 40, Continued

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	h^2
The biology taught at school is interesting.					.78										.70
The chemistry taught at school is interesting.										.81					.78
The physics taught at school is interesting.						.79									.75
Biology is a difficult subject.		.50			-.41										.54
Chemistry is a difficult subject.		.66													.68
Physics is a difficult subject.		.55				-.45									.63
Biology is difficult when it involves calculations.		.65													.55
Chemistry is difficult when it involves calculations.		.79													.74
Physics is difficult when it involves calculations.		.66				-.42									.68
Biology is difficult when it involves handling apparatus.									.77						.74

continued . . .

Table 40, Continued

Item Statement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	h^2
Chemistry is difficult when it involves handling apparatus.									.80						.74
Physics is difficult when it involves handling apparatus.									.76						.71
There are too many facts to learn in biology.					-.47							.61			.68
There are too many facts to learn in chemistry.												.73			.77
There are too many facts to learn in physics.						-.45						.65			.74
Biology is relevant to everyday life.					.47						.64				.68
Chemistry is relevant to everyday life.											.74				.71
Physics is relevant to everyday life.											.68				.67

[a] Factor loadings less than absolute .40 are not reported, and h^2 indicates the communality of an item.

Senior Division: Summary

Senior division students tend to report better marks in mathematics than in science, compared to marks in other subjects. These students generally like science and mathematics as much as other school subjects. Almost all of the students have a calculator for use at school and at home. Although most of the students report having access to computers at school, three quarters of the respondents say they never use one. Most of the students are enrolled at the advanced level and intend to continue their education beyond high school; a majority expect to include science as a part of their future studies. Virtually every student reports doing homework each week, spending at least up to two hours weekly on homework. Most of these students spend some time doing science homework.

Most students say a textbook is used often in science classes; occasionally other books are also used. The teacher reminds students about the work covered in previous classes, explains the work to be covered in the current class, and gives a summary at the end of the class. Students rarely choose topics for study, and occasionally have an opportunity to provide ideas and suggestions for planning science lessons. The teacher performs demonstrations to explain scientific ideas. Students do laboratory work in small groups, according to the teacher's instructions or instructions in a manual. There is reportedly no opportunity for field work in senior division science classes.

Most students find school challenging and desire to get as much education as possible, although they disagree that they enjoy everything about school and the time they spend there. More girls than boys tend to respond positively to statements about school.

Senior division students agree that science is important to them personally and to the country as a whole. There is no pattern of clear agreement or disagreement on the harmful effects of science, and many students are uncertain about such issues. Students find biology, chemistry, and physics enjoyable and interesting school subjects. Biology appears to be more popular with girls than boys, while chemistry and physics are more favored by boys.

Most students agree that a knowledge of science is an important requirement for future jobs, and that science is a good field for creative people to enter. However, they are less certain that a knowledge of science is necessary for getting a good job. Although only 4% of the students want to become science teachers, they would be interested in other careers in science. Only about one out of every five students feels that jobs involving modern inventions such as computers would be particularly interesting.

Statistical analyses of the items in the attitude scale yield appropriate item discrimination values. The subscales are reliable; however, factor analysis of the 56 attitudinal items indicates that items cluster more on the basis of thematic considerations than on presumed content.

5.2 TEACHER SURVEY

BACKGROUND AND RATIONALE

The purpose of this study was to determine how teachers perceive science education. Elementary and secondary teachers responsible for teaching environmental studies (kindergarten through grade 3) or science (grade 4 through secondary school) were asked to complete questionnaires covering a variety of issues related to science education. The study constitutes one element of a kindergarten-through-secondary school review of science education conducted between November, 1986 and June, 1988 by the Peel Board of Education.

The Peel Science Review is based largely on Background Study 52 published in 1984 by the Science Council of Canada. Reference to Canadian data within the Peel Science Review document is for comparative purposes.

METHODOLOGY

This section describes the population and sample, instrumentation, and processes for data collection and data analysis.

Elementary Teachers: Population and Sample

The population from which the sample was drawn included all elementary teachers charged with delivery of the Peel Primary Environmental Studies program or Peel Science program, with the exception of teachers involved in program delivery of contained SLD, GLD, or Behavioural programs.

Lists of primary and junior generalists, teachers of science (grades 7 and 8), and teachers of the gifted were provided by the Peel Personnel Department. There were a total of 1,274 teachers identified on these lists, of which 592 were primary generalists, 563 junior generalists, 87 middle (grades 7 and 8) teachers of science, and 32 teachers of contained gifted classes in all three levels. A proportional random sample of teachers was drawn from each classification.

In total, 698 questionnaires were distributed as follows: 296 questionnaires to primary generalists; 283 questionnaires to junior generalists; 87 questionnaires to grade 7 and 8 science teachers, and 32 questionnaires to teachers of contained gifted classes.

Secondary Teachers: Population and Sample

Peel records indicated that there were 284 secondary school teachers timetabled to teach one or more classes of natural science during the 1986-87 school year. All these teachers were included in the secondary sample.

Instrumentation

Self-report questionnaires were developed for the elementary and secondary respondents. Several items on each questionnaire replicated items contained in an the instrument developed by The Science Council of Canada.

The questionnaire designed for elementary school teachers contained 30 questions. The first eight questions dealt with general demographic information, including gender, years of teaching experience, and academic qualifications. The next five questions asked teachers to describe teaching responsibilities and institutional arrangements. The third section of the questionnaire asked teachers about in-service, and the fourth and fifth sections focused on curriculum, instruction, and students' abilities and interests. Teachers were asked to identify a specific grade taught during the 1986-87 school year and to respond to questions in the fourth and fifth sections with that grade in mind.

The secondary school teachers' questionnaire contained 28 items which fell into the same five broad categories as contained in the elementary teachers' questionnaire; for the most part, identical items were included. Secondary teachers were asked to identify a specific course of study using a six-character common course code and to respond to the fourth and fifth sections of the questionnaire with that course in mind.

Elementary Teacher Data Collection

The questionnaires were sent via Peel Board courier directly to each of the teachers drawn for the sample. Respondents were asked to forward the completed questionnaires to the Consultant: Evaluation at the Peel Research Unit by February 27th, 1987. A total of 363 of the 698 questionnaires were returned, a response rate of 52%. This response rate means that elementary teacher trends must be interpreted with some caution.

Secondary Teacher Data Collection

Secondary school heads of science received sufficient copies of the questionnaire to distribute to each member of their respective science departments. The science heads were instructed to direct the teachers to complete the questionnaires with a specific course of study in mind, and to assign each teacher a different course so that as many courses of study as possible were represented. Respondents were asked to return completed questionnaires to the Consultant: Evaluation at the Peel Research Unit by February 27, 1987. A total of 202 of the 284 questionnaires were returned, a response rate of 71%.

Data Analysis

All completed questionnaires were assigned an I.D. number, and a coding system was developed for open-ended questions. All questionnaire responses were entered into the computer. The subsequent analyses included total frequency distributions, as well as breakdowns by level: primary/junior; middle (grades 7 and 8); and secondary (grades 9-13); by type of secondary school organization (9-12 or 7-13 and 9-13 combined); by levels of difficulty; and by courses of study. Cross tabulations by specific variables were also carried out.

RESULTS

Demographic Information

The demographic information indicates that, above the elementary level, Peel science teachers are primarily male, in the 36-to-45 age range, with a minimum of 10 years teaching experience. In contrast, science at the elementary level is taught primarily by females in the 36-to-45 age range, with more than 14 years teaching experience. (See Tables 1-4.)

The gender ratio differs with respect to the level being examined. The 3:1 female-to-male ratio at the early level (K-6) changes to a 2:1 ratio in favour of males at the middle level (7-8), to a complete reversal at the secondary level (9-13), where a 3:1 male-to-female ratio prevails. Examination of data on teaching experience by gender (Table 5) shows no marked difference in years of teaching experience for male and female science teachers at the early and middle levels. However, at the secondary level there is a gender-related disparity in years of teaching experience. According to Table 5, 56% of males have 14+ years of teaching experience, compared to 26% of females. Half of the female science teachers (51%) have less than 10 years of experience, compared to 15% of males in the same category.

Table 6 examines the number of years of teaching science in Peel. Consistent with overall teaching experience (Table 4), the majority of early (61%) and secondary (66%) level teachers have taught science for at least 10 years. However, at the middle level, although 82% of the teachers have a minimum of 10 years teaching experience (Table 4), only 42% have taught science for 10+ years (Table 6). In fact, 58% of these teachers have been teaching science for less than ten years, a situation which is very likely linked to yearly school reorganization.

When the length of science teaching is examined by gender (Table 7), female teachers at the early level show more years of experience teaching science than do male teachers. This trend is reversed at the middle and secondary levels, where males are characterized by more years of teaching experience in science. The least experienced science teachers, therefore, are males at the early level and females at the middle and secondary levels.

Table 1

Ages of Science Teachers in Peel

Age (years)	Early (K-6) (n=256) %	Middle (7-8) (n=67) %	Secondary (9-13) (n=202) %
Under 26	0	0	4
26-35	18	24	35
36-45	58	59	44
46-55	19	15	16
Over 55	4	2	2
Average age	42	40	39

Table 2

Gender of Science Teachers in Peel

Gender	Early (K-6) (n=256) %	Middle (7-8) (n=67) %	Secondary (9-13) (n=202) %
Male	24	66	74
Female	73	34	26

Table 3

Ages of Teachers in Peel, by Gender

Age	Early (K-6) Male (n=61) %	Early (K-6) Female (n=185) %	Middle (7-8) Male (n=43) %	Middle (7-8) Female (n=22) %	Secondary (9-13) Male (n=135) %	Secondary (9-13) Female (n=47) %
Under 26	0	1	0	0	2	8
26-35	18	8	21	32	28	51
36-45	66	56	65	46	47	36
46-54	12	22	12	23	19	4
55+	5	3	2	0	4	0

Table 4

Length of Teaching Experience in Peel

Teaching Experience (years)	Early (K-6) (n=256) %	Middle (7-8) (n=67) %	Secondary (9-13) (n=202) %
1	0	3	5
2-5	4	8	10
6-9	10	8	10
10-13	23	26	28
Over 14	63	56	46

Table 5

Length of Teaching Experience in Peel, by Gender

Teaching Experience (years)	Early (K-6) Male (n=61) %	Early (K-6) Female (n=187) %	Middle (7-8) Male (n=48) %	Middle (7-8) Female (n=22) %	Secondary (9-13) Male (n=135) %	Secondary (9-13) Female (n=47) %
1-5	3	5	9	14	10	34
6-9	8	11	9	7	5	17
10-13	23	23	18	28	29	23
Over 14	66	62	59	56	56	26

Table 6

Length of Teaching Science in Peel

Teaching Experience in Science (years)	Early (K-6) (n=256) %	Middle (7-8) (n=67) %	Secondary (9-13) (n=202) %
1	5	14	7
2-5	19	35	16
6-9	14	9	10
10-13	21	21	24
Over 14	40	21	42

Table 7

Length of Teaching Experience in Science in Peel, by Gender

Teaching Experience in Science (years)	Early (K-6) Male (n=61) %	Early (K-6) Female (n=178) %	Middle (7-8) Male (n=43) %	Middle (7-8) Female (n=22) %	Secondary (9-13) Male (n=135) %	Secondary (9-13) Female (n=47) %
1	0	100	55	44	30	70
2-5	24	76	56	44	54	46
6-9	23	77	50	50	56	44
10-13	36	64	100	0	74	26
Over 14	25	75	86	14	90	10

Educational Background

The majority of science teachers in Peel possess a university degree and therefore comprise a well qualified teaching force (Table 8). Middle level teachers are more likely (34%) than either early (14%) or secondary level teachers (19%) to have a postgraduate degree. Although there are no marked gender differences across the various levels related to basic educational qualifications, at both the early and secondary levels many more males than females have earned postgraduate degrees (Table 9). It also seems that younger teachers entering the profession are more highly qualified educationally than teachers who have 10+ years of teaching experience.

An examination of specific levels of education in science and science-related courses (Table 10) indicates that three quarters of all early level and one half of all middle level science teachers have taken neither a university level mathematics or science course. When this issue is examined by gender (Table 11), early and middle level female science teachers are more likely than males to be lacking university level courses in mathematics and science.

Table 8

Teachers' Level of Education in Peel

Level of Education	Early (K-6) (n=256) %	Middle (7-8) (n=67) %	Secondary (9-13) (n=202) %
Teacher's college diploma	21	6	8
Bachelor's degree	64	57	73
Post graduate degree	14	34	19

Table 9

Teachers' Level of Education in Peel, by Gender

Level of Education	Early (K-6)		Middle (7-8)		Secondary (9-13)	
	Male (n=61) %	Female (n=182) %	Male (n=42) %	Female (n=22) %	Male (n=134) %	Female (n=47) %
Teacher's college diploma	5	28	2	9	6	8
Bachelor's degree	66	63	60	55	72	83
Post graduate degree	20	9	38	36	22	8

Table 10

Teachers' Level of Education in Peel, by Specific Subjects

Level of Education	Mathematics %	Pure Science %	Applied Science %
Early level (K-6)			
- No univeristy study	78	74	92
- Undergraduate level	22	23	8
- Post graduate level	0	0	0
Middle level (7-8)			
- No univeristy	51	48	87
- Undergraduate level	49	52	10
- Post graduate level	0	0	0
Secondary level (9-13)			
- No university study	19	4	69
- Undergraduate level	81	96	31
- Post graduate level	0	0	0

Table 11

Teachers' Level of Education in Peel, by Specific Subjects and by Gender

Level of Education	Early (K-6) Male %	Early (K-6) Female %	Middle (7-8) Male %	Middle (7-8) Female %	Secondary (9-13) Male %	Secondary (9-13) Female %
Mathematics	(n=61)	(n=187)	(n=43)	(n=22)	(n=123)	(n=44)
- No university study	66	82	44	64	3	25
- Undergraduate level	34	18	56	36	97	75
- Post graduate level	0	0	0	0	0	0
Pure Science	(n=61)	(n=187)	(n=43)	(n=22)	(n=123)	(n=44)
- No university study	64	82	35	73	0	2
- Undergraduate level	36	18	65	27	100	98
- Post graduate level	0	0	0	0	0	0
Applied Science	(n=61)	(n=187)	(n=43)	(n=22)	(n=47)	(n=10)
- No university study	95	91	84	100	2	0
- Undergraduate level	5	9	16	0	98	100
- Post graduate level	0	0	0	0	0	0

Attitudes Towards Teaching Science

Peel teachers at all levels appear very satisfied with teaching science (Table 12). At least four out of every five teachers say they would not avoid teaching in this subject area. More secondary teachers (92%) than early (80%) or middle level teachers (79%) take this position. Among the few respondents who say they would avoid teaching science, no particular pattern of reasons is reported (Table 13).

A cross tabulation by gender (Table 14) shows a tendency for more male than female science teachers, especially at the middle level (88% vs 59%), to answer "no" to the question, "If you had a choice would you avoid teaching science altogether?" This suggests more satisfaction with teaching science among the male teachers.

Table 12

Responses to the Question: "If you had a choice, would you avoid teaching science altogether?"

Response	Early (K-6) (n=256) %	Middle (7-8) (n=67) %	Secondary (9-13) (n=202) %
Yes	13	18	6
No	80	79	92
Undecided	7	3	2

Table 13

Reasons for Avoiding Science Teaching in Peel

Reason	Early (K-6) (n=256) %	Middle (7-8) (n=67) %	Secondary (9-13) (n=202) %
Lack of resources	10	6	1
Inadequate background	8	10	3
Dislike of science	4	6	0
Working conditions	3	3	2
Student attitudes	1	0	0
Other	2	6	4

Table 14

Responses (by Gender) to the Question, "If you had a choice would you avoid teaching science altogether?"

Response	Early (K-6) Male (n=61) %	 Female (n=185) %	Middle (7-8) Male (n=43) %	 Female (n=22) %	Secondary (9-13) Male (n=135) %	 Female (n=47) %
Yes	8	14	9	36	3	6
No	88	77	88	59	96	92
Undecided	3	8	2	4	2	2

Importance of Science Objectives: Overview

Teachers at all levels were asked to assess the importance of the 14 science objectives outlined by the Science Council of Canada in "Science Education in Canadian Schools," Background Study 52 (Appendix A). As pointed out in the Science Council of Canada Study, teachers may not be the best judges of their own performance; therefore, their self-evaluations of effectiveness may be suspect. Instead, this data should be interpreted to indicate curriculum areas in which teachers feel the most and least comfortable. This type of interpretation provides valuable information when practical inservice programs are being designed.

Importance of Science Objectives: Early Level (K-6)

Early level teachers indicate three objectives as being particularly important (Table 15). These objectives are related to social skills, attitudes appropriate to scientific endeavour, and investigative skills and processes. The Canadian data shows a similar pattern.

The remaining objectives can be clustered into two groups. The first group contains seven objectives which elicit moderate-to-high concensus among teachers (55%-84%). The remaining group of four objectives shows the least teacher concensus in terms of importance (24%-37%).

Teachers were also asked to indicate their degree of effectiveness in achieving these 14 objectives. At the early level there is a positive correlation between objectives ranked as important and teachers' level of perceived effectiveness (Table 16): the objectives that are ranked as most important are also the ones in which the teachers feel the most effective. Within the second cluster group of seven objectives, there are three objectives in which a majority of early teachers perceive themselves as ineffective. These are: understanding the relevance of science to the needs and interests of men and women; understanding the role and significance of science in modern society; and understanding the way that scientific knowledge is developed. It would appear from the responses obtained for the objectives in the third cluster group that these objectives have not been implemented at the early level to any significant degree.

The importance of science objectives at the early level was cross tabulated by gender and teaching experience. There are no marked differences in importance of the 14 objectives between male and female science teachers or on the basis of teaching experience.

Table 15

Importance of Objectives in Peel: Early Level (K-6)

Rank	Objective	% Assessing as Fairly or Very Important
1.5	Developing social skills.	96
1.5	Developing attitudes appropriate to scientific endeavour.	96
3	Developing skills and processes of investigation.	96
4	Developing the skills of reading and understanding science-related materials.	84
5	Relating scientific explanation to the student's conception of the world.	80
6	Understanding the practical applications of science.	79
7	Understanding the relevance of science to the needs and interests of men and women.	72
8.5	Understanding scientific facts, concepts, laws, etc.	68
8.5	Understanding the role and significance of science in modern society.	68
10	Understanding the way that scientific knowledge is developed.	55
11	Developing an awareness of the practice of science in Canada.	37
12	Relating science to career opportunities.	32
13	Understanding the nature and processes of technological or engineering activity.	26
14	Understanding the history and philosophy of science.	24

Table 16

Effectiveness of Science Teachers in Achieving Objectives in Peel: Early Level (K-6)

Rank (Importance)	Objective	% Assessing as Fairly or Very Effective
1.5	Developing social skills.	93
1.5	Developing attitudes appropriate to scientific endeavour.	93
3	Developing skills and processes of investigation.	92
4	Developing the skills of reading and understanding science-related materials.	79
5	Relating scientific explanation to the student's conception of the world.	66
6	Understanding the practical applications of science.	62
7	Understanding the relevance of science to the needs and interests of men and women.	39
8.5	Understanding scientific facts, concepts, laws, etc.	67
8.5	Understanding the role and significance of science in modern society.	43
10	Understanding the way that scientific knowledge is developed.	36
11	Developing an awareness of the practice of science in Canada.	18
12	Relating science to career opportunities.	19
13	Understanding the nature and processes of technological or engineering activity.	14
14	Understanding the history and philosophy of science.	14

Importance of Science Objectives: Middle Level (7-8)

Middle level teachers indicate that 10 of the 14 objectives are very important (Table 17). These objectives are apparently more emphasized in the middle than in the early level. The remaining four objectives can be divided into two groups of two objectives each, based on the degree of concensus regarding importance.

The overall rank ordering of the importance of the 14 objectives for the middle level closely resembles the ranking for the early level. In addition to the three objectives which early level teachers consider particularly important (social skills, attitudes appropriate to scientific endeavour, and investigative skills and processes), middle level teachers add seven additional objectives: practical applications of science; content; skills of reading and understanding science-related materials; role and significance of science in modern society; relating scientific explanation to students' conception of the world; understanding how knowledge is developed; and understanding the relevance of science to the needs and interests of men and women.

Two of the four remaining objectives receive moderate concensus: career opportunities (68%), and understanding the nature and processes of technological activity (53%). Less than half of the middle level teachers feel that the two remaining objectives are important: awareness of science in Canada (46%), and understanding the history and philosophy of science (43%).

The findings for middle level teachers seems to reflect the Ministry's expectation that a broader range of areas will be addressed by middle level than by early level teachers.

When asked to measure their own effectiveness with respect to the 14 objectives, the responses of the middle level teachers show a strong relationship to their ratings of importance for the 14 objectives -- that is, high effectiveness ratings for objectives seen as fairly or very important (Table 18). This trend is somewhat less strong for three objectives in the top cluster: understanding the role and significance of science in modern society; understanding the way that scientific knowledge is developed; and understanding the relevance of science to the needs and interests of men and women. The four objectives ranked lower in importance by middle level teachers are also areas where they indicate a lower degree of effectiveness.

It is interesting to compare Peel and the Canadian sample of middle level teachers on both the importance of the 14 objectives and the perceived effectiveness in achieving these objectives. The objective, "understanding the practical applications of science," is tied for top rank in terms of its importance and perceived effectiveness among Peel teachers, compared to a ranking of 5 in the Canadian study.

As is the case with the early level teachers, there are no marked differences in perceived importance of the 14 objectives by gender. In terms of teaching experience, middle level teachers with 10+ years of experience are much more likely to rate the objective, "understanding the role of science in modern society," as important (71%) than are teachers with less than 10 years of experience (17%).

Table 17

Importance of Objectives in Peel: Middle Level (7-8)

Rank	Objective	% Assessing as Fairly or Very Important
1.5	Understanding the practical applications of science.	96
1.5	Developing skills and processes of investigation.	96
3	Developing attitudes appropriate to scientific endeavour.	94
4	Developing social skills.	91
5.5	Understanding scientific facts, concepts, laws etc.	90
5.5	Developing the skills of reading and understanding science-related materials.	90
7	Understanding the role and significance of science in modern society.	86
8	Relating scientific explanation to the students' conception of the world.	85
9	Understanding the way that scientific knowledge is developed.	80
10	Understanding the relevance of science to the needs and interests of men and women.	79
11	Relating science to career opportunities.	68
12	Understanding the nature and processes of technological or engineering activity.	53
13	Developing an awareness of the practice of science in Canada.	46
14	Understanding the history and philosophy of science.	43

Table 18

Effectiveness of Science Teachers in Achieving Objectives in Peel: Middle Level (7-8)

Rank (Importance)	Objective	% Assessing as Fairly or Very Effective
1.5	Understanding the practical applications of science.	91
1.5	Developing skills and processes of investigation.	95
3	Developing attitudes appropriate to scientific endeavour.	94
4	Developing social skills.	94
5.5	Understanding scientific facts, concepts, laws etc.	94
5.5	Developing the skills of reading and understanding science-related materials.	87
7	Understanding the role and significance of science in modern society.	69
8	Relating scientific explanation to the students' conception of the world.	82
9	Understanding the way that scientific knowledge is developed.	67
10	Understanding the relevance of science to the needs and interests of men and women.	63
11	Relating science to career opportunities.	46
12	Understanding the nature and processes of technological or engineering activity.	39
13	Developing an awareness of the practice of science in Canada.	22
14	Understanding the history and philosophy of science.	36

Importance of Science Objectives: Secondary Level (9-13)

Secondary level teachers rate 8 of the 14 objectives as fairly or very important: investigative skills and processes; practical applications; attitudes, appropriate to scientific endeavour; scientific explanation; content; social skills; reading; and understanding the role of science in modern society (Table 19). The remaining six objectives can be grouped into two categories, based on the degree of concensus. Moderate agreement about importance (56%-77%) is noted for these objectives: understanding the relevance of science to men and women; career opportunities; understanding how scientific knowledge is developed; and understanding the nature and processes of technological activity. As is found for middle level teachers, understanding the history and philosophy of science (42%), and developing an awareness of science in Canada (36%) rank lowest in terms of importance.

Secondary teachers express confidence about their effectiveness in accomplishing these objectives in the science classroom (Table 20). They tend to rate the objectives which they see as most important as the areas in which they are the most effective. Of the eight top ranked objectives, the teachers feel they are the most effective in "understanding scientific facts, concepts, laws, etc." (95%). Understanding the relevance of science to both men and women is an objective rated as important (76%), but one for which teachers indicate only moderate effectiveness (56%). Although Peel results are generally similar to the Canadian data, Peel secondary science teachers view themselves as more effective than the Canadian sample in the areas of developing social skills and understanding the practical applications of science.

Only one objective shows a sizeable difference between male and female respondents: "understanding the nature and processes of technological or engineering activity." More male (64%) than female (38%) teachers rate this as an important objective. Response trends are similar for secondary level teachers with different amounts of teaching experience.

Table 19

Importance of Objectives in Peel: Secondary Level (9-13)

Rank	Objective	% Assessing as Fairly or Very Important
1	Developing skills and processes of investigation.	96
2	Understanding the practical application of science.	96
3	Developing attitudes appropriate to scientific endeavour.	94
4	Relating scientific explanation to the student's conception of the world.	92
5	Understanding scientific facts, concepts, laws etc.	92
6	Developing social skills.	91
7	Developing the skills of reading and understanding science-related materials.	89
8	Understanding the role and significance of science in modern society.	85
9	Understanding the relevance of science to the needs and interests of men and women.	76
10	Relating science to career opportunities.	68
11	Understanding the way that scientific knowledge is developed.	65
12	Understanding the nature and processes of technological or engineering activity.	56
13	Understanding the history and philosophy of science.	42
14	Developing an awareness of the practice of science in Canada.	36

Table 20

Effectiveness of Science Teachers in Achieving Objectives in Peel: Secondary Level (9-13)

Rank (Importance)	Objective	% Assessing as Fairly or Very Effective
1	Developing skills and processes of investigation.	91
2	Understanding the practical application of science.	92
3	Developing attitudes appropriate to scientific endeavour.	89
4	Relating scientific explanation to the student's conception of the world.	82
5	Understanding scientific facts, concepts, laws etc.	95
6	Developing social skills.	92
7	Developing the skills of reading and understanding science-related materials.	79
8	Understanding the role and significance of science in modern society.	70
9	Understanding the relevance of science to the needs and interests of men and women.	56
10	Relating science to career opportunities.	56
11	Understanding the way that scientific knowledge is developed.	63
12	Understanding the nature and processes of technological or engineering activity.	41
13	Understanding the history and philosophy of science.	38
14	Developing an awareness of the practice of science in Canada.	23

Obstacles to Achievement of the 14 Science Objectives

The achievement of the 14 science objectives in the classroom can be affected by a variety of different factors. Teachers were asked to indicate the importance of eight factors as obstacles in the achievement of the 14 science objectives. Table 21 shows early, middle, and secondary level teachers' perceptions of these eight factors.

A majority of early (82%), middle (85%), and secondary (76%) teachers indicate the factor "institutional arrangements" as an obstacle of great concern. Early level teachers also specify "physical facilities and equipment" (88%) and "curriculum resources" (81%) as substantial barriers to the achievement of objectives in the science classroom; 62% of the early teachers also mention "support of Peel resource staff". Middle and secondary level teachers note that "students' abilities and interests" are areas of concern (74% and 76%, respectively); 58% of early level teachers share this perception. About two thirds of middle level teachers mention "physical facilities and equipment" and "curriculum resources" as obstacles. The corresponding percentages for secondary level teachers are 52% and 60%, respectively.

Table 21

Obstacles to the Achievement of Objectives in Peel

Areas Containing Potential Obstacles	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Teachers' background and experience	47	45	30
Physical facilities and equipment	88	65	52
Students' abilities and interests	58	71	76
Institutional arrangements (e.g. class size)	82	85	76
Support of school administration	55	45	34
Support of Peel resource staff	62	42	25
Community support	30	20	13
Curriculum resources	81	66	60

Curriculum Resources

Table 22 presents teachers' perceptions of the importance of various resources for planning instruction. Since early level teachers are primarily generalists, they rely heavily on curriculum documents developed at the Board level (85%). The individual school library is also considered an excellent source of materials to assist the early level science teacher in instructional planning (92%). Three quarters of the early teachers find Peel media resources quite useful, and 64% also utilize commercially published curriculum materials. About half of these teachers use Ministry support documents (54%), TV or radio programs (56%), other media resources (49%), and science magazines, journals, and newsletters (48%).

Middle level teachers rely mainly on Board curriculum material (75%) and provincially approved texts (75%). Other science textbooks (68%) also receive emphasis in the instructional plan. The school resource centre (63%) and material developed at the school level (61%) are other resources fairly well utilized by middle level teachers. About half of the middle level teachers also use Ministry policy statements (49%), Ministry support documents (51%), Peel media resources (55%), and science magazines, journals, and newsletters (52%).

At the secondary level, teachers rely most on school developed courses of study (78%) and provincially approved texts (70%) as major instructional resources. Ministry guidelines do not appear to be extensively used as a resource in instructional planning by teachers, especially in the early and secondary levels (36% early, 49% middle, and 23% secondary).

Teachers were also asked to identify agencies responsible for various tasks associated with science curricula (Table 23). No clear response trends emerge on this question. Teachers — especially at the secondary level — tend to feel that lesson plans and teaching strategies are the responsibility of individual teachers. Early and middle level teachers see the regional co-ordinator or a regional committee of teachers as responsible for identifying resources. There is some tendency for teachers to view evaluation methods as the responsibility of individual schools and/or teachers.

Table 22

Resources for Planning Instruction in Peel

Resources	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Ministry policy statements	36	49	23
Provincially approved texts	20	75	70
Other science texts	28	68	23
Ministry support documents	54	51	22
Peel board curriculum material	85	75	26
School developed plans or courses of study	46	61	78
Commercially published curriculum materials	64	46	26
Peel media resources	74	55	24
T.V. or radio programs	56	44	16
Other media resources	49	45	22
Publications from government departments	22	19	22
Materials from teachers' associations	30	19	19
Science magazines, journals, newsletters etc.	48	52	15
Industrially sponsored free materials	20	24	25
Materials from the school library	92	63	18
Computer software	40	21	18

Table 23

Teachers' Perception of the Agencies Responsible for Addressing Specific Tasks Associated with Newly Developed Science Programs

Task	Ministry of Education			Regional Co-ordinator			Teacher Committee (Regional)			Family Schools Committee			Individual Schools			Individual Teachers		
	E* %	M* %	S* %	E %	M %	S %	E %	M %	S %	E %	M %	S %	E %	M %	S %	E %	M %	S %
Preparing long range plans	10	25	19	34	31	8	18	23	40	5	3	4	11	12	22	22	6	8
Preparing lesson plans	1	2	2	14	14	1	19	29	6	1	2	2	11	9	7	54	46	83
Identifying resources	3	3	8	54	67	25	19	24	38	10	2	7	12	3	14	3	2	9
Deciding teaching strategies	1	0	3	11	9	1	18	20	8	4	4	0	17	14	21	49	53	70
Deciding evaluation methods	2	2	4	8	5	0	15	22	10	3	3	1	22	31	46	50	38	38

* "Early" (E) means K-6
* "Middle (M) means 7-8
* "Secondary" (S) means 9-13

Instructional Time

Table 24 illustrates that 67% of early level teachers and 73% of middle level teachers believe that the amount of time allocated to science in Peel is "about right" or "adequate," relative to other subject disciplines.

Table 25 shows that a majority of early level teachers (64%) spend up to 2 hours per week on science instruction; another 19% say they spend 2-3 hours weekly on science. Program operating procedure 9 directs 2 hours at the junior level. About two thirds of middle level teachers (68%) spend 2-3 hours weekly on science, with another 21% reporting 1-2 hours. Program Operating Procedure 9 specifies 2.67 hours of science instruction weekly at the middle level.

Table 26 indicates that teachers at all three levels are about equally divided on the issue of whether there is sufficient time available to cover the science curriculum. Approximately half the teachers estimate "too little" and half feel there is "just enough" time.

Table 24

Teachers' Perception of Time Allocated to Science in Peel

Perception	Early (K-6) (n=256) %	Middle (7-8) (n-67) %
Inadequate	33	27
About right	51	55
Adequate	16	18

Table 25

Teachers' Estimation of the Number of Hours of Science Instruction Per Week in Peel

Time (Hours)	Early (K-6) (n=256) %	Middle (7-8) (n-67) %
Less than 1	33	4
Between 1 and 2	31	21
2-3	19	68
Greater than 3 hours	0	4
Integrated	10	0
Varies	4	0

Table 26

Teachers' Perception of Time Available to Cover the Science Curriculum

Perception	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Too little	52	47	46
Just enough	44	47	52
More than enough	4	6	2

Instructional Strategies

Teachers at all levels were asked to indicate how frequently they effectively used a variety of pedagogical techniques (Table 27). A large majority of teachers at all three levels (83% - 94%) report the effective use of "teacher directed instruction" and "small group investigation." Approximately 60% of teachers at all three levels utilize "individual student in-class investigation/experimentation." Field trips are much more extensively used by early level teachers (77%) than by middle (45%) or secondary level teachers (14%). "Individually contracted study" is a strategy used by about half of the middle level teachers (52%), by one third of the early level teachers (34%), and by only 17% of the secondary level teachers.

Overall, there appears to be a somewhat limited number of pedagogical techniques currently in use in the science classroom.

Table 27

Instructional Strategies Used to Achieve Science Objectives in Peel

Strategy	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Teacher directed instruction	90	90	94
Small group investigation	93	84	83
Individual student in-class investigation/ experimentation	63	60	62
Field trips	77	45	14
Outside speakers	27	6	13
Individually contracted study	34	52	17
Other	22	50	36

Evaluation Methods

Teachers were asked to indicate which evaluation methods were used in the calculation of a student's final science grade. Teachers' responses are presented in Table 28. Evaluation at the early level is based primarily on informal observation (87%). These teachers also utilize observational check lists and/or rating scales (67%) and oral presentations (64%) in measuring student achievement. Slightly more than half of the early level teachers rely on notebooks and homework checks (57%), and 52% find take-home assignments useful in determining students' grades.

Almost all of the middle level teachers (94%) favour the use of take-home projects or assignments; a large number of these teachers also use objective test items (83%), test items requiring one or more sentences (79%), and notebooks/homework checks, (76%) in making evaluation decisions. Six out of ten teachers prefer test items requiring full solutions to problems, and about half of the teachers rely on oral presentations (54%).

Table 28 shows that secondary level teachers favour evaluation methods that are linked to tests and formal examinations. A sizeable majority of these teachers (72% to 86%) use the following methods to evaluate student achievement: objective-type test and examination items; test and examination items requiring one or more sentences to answer; and test and examination items requiring full solution problems. Take-home projects and assignments are another evaluation method used by a majority of secondary teachers (71%).

Student involvement in the establishment of evaluation criteria or in self-evaluation appears to be rarely implemented in Peel (Table 29). Self-evaluation is reported by 42% of early teachers, by 24% of middle teachers, and by 12% of secondary teachers. Involving students in establishing criteria for evaluation is higher at the early (26%) and middle levels (28%) than at the secondary level (8%).

As one moves through the three teaching levels, there appears to be a shift in evaluation techniques from a more student-centered approach at the early level to a more content/knowledge-based approach at the secondary level. (This issue will be further examined in a report dealing with examination analyses, another aspect of the Peel Science Review.) The area of evaluation, one of the three major components of Peel's Program to Assist Classroom Excellence program, appears to be an area on which to focus in on-going inservice training for science teachers at all levels.

Table 28

Evaluation Methods Used to Measure Attainment of Science Objectives in Peel

Evaluation Methods	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Informal observation	87	42	14
Observations using checklists and/or rating scales	67	46	24
Take-home projects or assignments	52	94	71
Items on tests requiring objective responses	38	83	84
Items on tests requiring one or more sentences	37	79	86
Items on tests requiring full solution problems	14	61	71
Items on formal examinations requiring objective reponses	N/A	N/A	81
Items on formal examintations requiring one or more sentence responses	N/A	N/A	82
Items on formal examinations requiring full solutions to problems	N/A	N/A	72
Notebooks, homework checks	57	76	33
Oral presentations	64	54	10
Other	42	33	39

Table 29

Student Involvement in Science Evaluation in Peel

Aspect	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Involvement of students in the establishment of evaluation criteria	26	28	8
Involvement of students in peer or self-evaluation	42	24	12

Inservice Programs

In order to implement successfully the 28 new Ministry science guidelines, school boards must develop specially designed inservice programs to meet specific teacher needs.

Regardless of the level taught, the number of years of teaching experience, age, or gender, a majority of teachers report either that science inservice is non-existent or ineffective (Table 30). It is encouraging that a majority of teachers at all levels are willing to participate in inservice programs (Table 31). The granting of release time to enable participation in inservice is preferred to inservice outside of school hours.

Peel science teachers appear to value the expertise of their colleagues. When teachers rate the value of various inservice experiences (Table 32), a preference for informal meetings with other science teachers is seen for middle (78%) and secondary teachers (94%). All three levels feel that workshops presented by other teachers are useful (51%, 69%, and 67%, respectively), and workshops presented by resource teachers are rated highly by half of the early (48%) and middle level teachers (51%). Middle level teachers also prefer meetings with a co-ordinator/consultant (48%). A large majority of secondary level teachers (85%) report that consultation with the department head is useful; about two thirds of these teachers also value visits to colleagues' schools or classrooms (69%) and conferences related to science education (65%).

It is interesting to note, as did the Science Council of Canada study, that many early level teachers report that they have no experience with most of the inservice formats listed in Table 32. For example, about three quarters of all early level teachers (78%) have never attended a conference related to science education. Perhaps other subjects have taken precedence, due to the generalist nature of the elementary teacher's role.

Table 30

Teachers' Assessment of the Effectiveness of Science Inservice Programs in Peel

Assessement	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Nonexistent	39	20	38
Completely or fairly ineffective	48	42	46
Fairly or very effective	14	38	16

Table 31

Teachers' Participation in Science Inservice Education in Peel

Circumstances	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
During school hours if release time was given	96	97	90
At a convenient time outside school hours	76	68	68

Table 32

Value of Science Inservice Education Experiences

In-Service Experience	Completely or Fairly Useless			Fairly or Very Useful			No Experience		
	Early	Middle	Secondary	Early	Middle	Secondary	Early	Middle	Secondary
	%	%	%	%	%	%	%	%	%
Informal meeting with other science teachers	8	6	5	37	78	94	55	16	1
Workshop by other teachers	6	4	19	51	69	67	43	27	13
Workshops by resource teachers	6	15	31	56	64	37	38	21	33
Consultation with resource teachers	9	27	26	48	51	29	43	22	45
Consultation with co-ordinator or consultant	8	15	35	22	48	28	70	37	37
Consultation with principal or vice-principal	16	30	38	24	39	36	61	30	26
Visits to other teachers schools or classrooms	4	3	10	36	42	69	60	54	21
Conferences or meetings by science teacher or organization	5	2	10	17	46	65	78	52	24
Consultation with department head	–	–	10	–	–	85	–	–	5

Teachers' Perceptions of Students' Attitudes, Abilities, and Achievement

Peel teachers are very optimistic with respect to students' attitudes and abilities in the area of science (Tables 33 and 34). A sizeable majority of teachers at all levels (83%-89%) feel that students are fairly or highly motivated to learn science. Similarly, 71%-79% of teachers at the three levels believe that student ability to undertake science courses is fairly or completely adequate. It is interesting that when teachers were asked to specify obstacles to achieving science objectives in the classroom, 58% of teachers at the early level, 71% at the middle level, and 76% at the secondary level indicate that students' abilities and interests constitute important obstacles (Table 21).

Table 35 represents teachers' perceptions of differences in the attitudes, abilities, and achievement of male and female students. At all levels, a majority of teachers perceive no gender differences on student motivation, ability, or achievement. This same overall trend is noted when the responses of male and female teachers are considered separately (Table 36). However, at the middle and secondary levels, female science teachers tend to believe that females achieve higher grades than male students (Table 36).

Table 33

Students' Attitude Toward Learning Science in Peel

Students' Attitude	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Reluctant	0	4	4
Indifferent	5	12	14
Fairly motivated	52	70	60
Highly motivated	37	14	23

Table 34

Students' Background and Abilities in Peel

Student's Background and Ability	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Completely inadequate	3	3	5
Fairly inadequate	21	21	17
Fairly adequate	56	67	60
Completely adequate	16	4	19

Table 35

Attitudes, Abilities and Achievement of Male and Female Students in Peel

Teachers' Perceptions	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Attitudes			
- Females are more motivated than males	1	4	13
- No difference	86	84	77
- Males are more motivated than females	13	12	10
Abilities			
- Females are more able than males	2	9	5
- No difference	94	90	91
- Females are more able than males	4	2	4
Achievement			
- Females achieve higher grades than males	9	19	14
- No difference	87	78	77
- Males achieve higher grades than females	4	3	9

Table 36

Attitudes, Abilities and Achievement of Male and Female Students, by Gender of Teacher in Peel

Teachers' Perceptions	Early (K-6) Male (n=61) %	Early (K-6) Female (n=185) %	Middle (7-8) Male (n=43) %	Middle (7-8) Female (n=22) %	Secondary (9-13) Male (n=135) %	Secondary (9-13) Female (n=47) %
Attitudes	(n=58)	(n=182)	(n=43)	(n=22)	(n=135)	(n=47)
- Females more motivated than males	0	1	5	4	13	13
- No difference	85	86	84	86	78	72
- Males more motivated than females	15	13	12	9	9	15
Abilities	(n=58)	(n=182)	(n=43)	(n=22)	(n=135)	(n=47)
- Females more able than males	5	1	9	4	5	2
- No differences	90	96	91	91	90	96
- Males more able than females	5	3	0	4	5	2
Achievement	(n=59)	(n=179)	(n=93)	(n=22)	(n=135)	(n=47)
- Females achieve higher grades than males	9	8	14	27	12	15
- No difference	81	89	81	73	76	83
- Males achieve higher grades than females	10	2	5	0	12	2

Physical Facilities for Science Teaching

Table 37 shows early and middle level teachers' assessments of physical facilities available to them for science teaching. A sizeable majority of early level teachers (85%) rate facilities as "poor" or "very poor." This assessment is directly related to the fact that, as shown in Table 38, most early teachers (93%) do not teach in specially designed science laboratories or classrooms. This finding is also consistent with data reported earlier in this report, on perceived obstacles to achieving science objectives (Table 21). On that question, 88% of early teachers specify "physical facilities and equipment" as an important obstacle.

Middle level teachers are about equally split in their assessment of facilities: 58% rate the facilities as "good" or "excellent," and 42% feel they are "poor" or "very poor." In an earlier section of this report (Table 21), 65% of middle teachers are reported as saying that "physical facilities and equipment" are an obstacle to achieving science objectives. Examination of Table 38 shows that 57% of middle teachers teach science in a laboratory or science classroom; another 10% have access to a laboratory, and 13% teach in a classroom with demonstration facilities.

Table 37

Quality of Facilities in Peel

Teachers' Assessment	Early (K-6) (n=256) %	Middle (7-8) (n-67) %
Very poor	44	12
Poor	41	30
Good	14	52
Excellent	1	6

Table 38

Facilities for Science Teaching in Peel

Facility	Early (K-6) (n=256) %	Middle (7-8) (n-67) %
A laboratory or specially designed science room	0	57
A classroom with occassional access to a laboratory	2	10
A class with facilities for demonstration only	5	13
A classroom with no special facilities for science	93	19

Institutional Arrangements for Science Teaching

The factor, "institutional arrangements" was ranked high by a majority of teachers at all levels as an important obstacle to the achievement of objectives in the science classroom (Table 21). The range of subjects taught by early, middle, and secondary teachers is shown in Table 39. A large majority of early level teachers (86%) teach a variety of subjects (i.e., they are generalists). At the middle level, 31% of the teachers teach a variety of subjects, and 57% teach science and English. Only 24% teach science only. At the middle level, therefore, relatively few teachers are science specialists.

Table 10 shows that secondary level teachers are the most likely to have educational background in mathematics, pure science, and applied science. It is not surprising, then, that 75% of these teachers are timetabled for science only (Table 39).

Table 40 indicates that, at the secondary level, the more experienced a teacher is, the more likely he/she is to teach science only. Earlier in this report (Table 7) it was noted that among secondary science teachers, males were more likely than females to have more years of teaching experience. Thus, it is not surprising that secondary level male teachers are more likely to be timetabled for science only, compared to female teachers (86% vs 60%; see Table 41). Therefore, females are more likely to be teaching in more than one subject area at the secondary level.

As described in the methodology section, science heads were asked to distribute questionnaires to all members of their departments. For certain questionnaire items, each teacher was to focus on a particular course of study, as specified by the department head. This information was used to generate the percentages of males and females teaching specific courses (Table 42). This data may not accurately reflect the actual gender representation in specific courses and levels of difficulty, but rather the heads' perception of teacher expertise by gender. Table 42 illustrates that female science teachers responded to questionnaires primarily in middle advanced and general level courses. A significant number of males in comparison to females were directed to respond to advanced level secondary courses. No female science teachers responded to secondary advanced level physics courses.

Table 39

Subjects Taught by Science Teachers in Peel

Subjects	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Science only	3	24	75
Science and mathematics	0	10	8
Science and physical education	0	0	8
Science and family studies	0	0	2
Science and geography			1
Science and technological studies	0	5	1
Science and history			1
Science and guidance	0	0	1
Science and computer studies	0	5	4
Science and English	1	57	1
Science and art	0	5	0
Science and social studies	0	10	0
Science and French	0	0	0
A variety of subjects	86	31	2

Table 40

Subjects Taught by Length of Teaching Experience in Peel: Secondary Level (9-13)

Subjects	1 (n=9) %	2-5 (n=20) %	6-9 (n=16) %	10-13 (n=49) %	14+ (n=86) %
Science only	33	50	62	80	93
Science and math	33	15	7	4	4
Science and physical & health education	11	15	25	10	-
Science and family studies	-	5	-	2	1
Science and geography	-	-	-	2	-
Science and technical	-	-	-	-	1
Science and history	11	-	-	-	-
Science and guidance	-	-	-	-	1
Science and computer studies	11	5	6	-	-
Science and English	5	-	-	-	-
Science and 2 others	5	-	2	-	-

Table 41

Subjects Taught by Gender in Peel: Secondary Level (9-13)

	Gender	
Subjects	Male (n=134) %	Female (n=45) %
Science only	86	60
Science and mathematics	4	16
Science and physical education	5	11
Science and family studies	0	7
Science and geography	1	0
Science and history	0	2
Science and technical studies	1	0
Science and guidance	1	0
Science and computer studies	2	0
Science and English	0	2
Science and social studies	0	0

Table 42

Subjects Taught, by Gender: Secondary Level (9-13)

Subjects	n	Gender Male %	 Female %
All basic courses	20	60	40
Middle 9/10 general	22	68	32
Secondary general (all)	31	68	32
Middle 9/10 advanced	29	52	48
Secondary advanced (all)	95	87	13
Secondary advanced biology	24	75	25
Secondary advanced chemistry	33	91	9
Secondary advanced physics	29	100	0
Grade 11/12 advanced	39	87	13
OAC's	47	92	8

Leadership in Science Programs

Early and middle levels teachers were asked to identify the form of leadership in science at the school level (Table 43). A majority of early level teachers (74%) indicate that there is no particular leadership in place. These results are congruent with the Canadian data and are indicative of school organization at the primary and junior levels. At the middle level, 59% of the teachers specify a group of teachers at the school level as providing leadership; the remaining 41% indicate that there is no particular form of leadership. These results have important implications with respect to the review, delivery, and implementation of science in Peel's elementary schools.

It was assumed that secondary school organization would assign leadership functions in science to the department head and the school adminsitrators.

Table 43

Leadership in Science at the School Level in Peel

Form of Leadership	Early (K-6) (n=256) %	Middle (7-8) (n=67) %
A group of teachers	22	59
School administration	4	0
No particular leadership	74	41

Special Education and Science Education

The mainstreaming of students with special needs demands that teachers possess practical knowledge and understanding of the range of modifications that can be effectively utilized. Table 44 indicates the percentage of Peel science teachers with special education qualifications. Only 38% of early teachers, 28% of middle teachers, and 28% of secondary teachers have these qualifications. About half of the teachers who are qualified in special education have earned only Part 1 certification (Table 45).

Middle teachers are more likely (76%) than either early (61%) or secondary (35%) teachers to report exceptional students in their classrooms (Table 46). Slightly more than half of the teachers (52%-56%) report either minimal or no liaison with the special education teacher in their school (Table 47). There is, however, no indication as to whether teachers desire (or in fact require) additional liaison to be successful with the identified exceptional students in their classrooms.

Teachers at all levels were asked to record any modifications in instruction and evaluation employed for exceptional students. A variety of modifications are apparently being implemented at all grade levels. Instructional modifications mentioned are: variety of instructional approaches; individualized instruction; decrease in teacher oriented activities; use of computers; increased resources for students; student modular approach; more 'hands-on' laboratories; more reading, writing, oral instruction, discussion; and more assignments in general.

Modifications to evaluation include: greater emphasis on written work, projects, presentations, experiments, and participation; variation in testing and format of test; extended time on tests and examinations; less emphasis on spelling; and decrease in the number of tests and assignments.

A number of teachers at each level indicate that no modifications to instruction or evaluation are utilized for exceptional students.

Table 44

Special Education Qualifications in Peel

Response	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Yes	38	28	28
No	62	72	72

Table 45

Level of Special Education Certification in Peel

Response	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Part 1	50	50	60
Part 2	22	25	21
Specialist	28	25	17

Table 46

Teachers with Exceptional Students in Their Classes in Peel

Exceptional Students	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Yes	61	76	35
No	39	24	65

Table 47

Extent of Science Teacher Liaison with Special Education Teachers in Peel

Degree of Liaison	Early (K-6) (n=256) %	Middle (7-8) (n-67) %	Secondary (9-13) (n=202) %
Extensive liaison	14	11	7
Moderate liaison	34	34	36
Minimal liaison	32	39	31
No liaison	20	16	25

5.3 PRINCIPAL, SUPERINTENDENT, AND RESOURCE TEACHER INTERVIEWS/SURVEYS

BACKGROUND AND RATIONALE

This study constitutes one element of a kindergarten-through-secondary review of science education conducted between November, 1986 and June, 1988 by The Peel Board of Education.

The purpose of this study was to determine how principals, superintendents of schools, and resource teachers perceive science education in Peel. Elementary and secondary principals, and superintendents of schools were interviewed in person on a variety of issues related to science education, such as: science objectives, gender differences, inservice, obstacles, leadership, and school requests. Resource teachers were asked to complete a questionnaire containing similar questions.

The majority of the interview questions were developed from the findings of the teacher survey portion of the science review.

METHODOLOGY

Elementary principals: population and sample

The population included all principals of Peel elementary schools, as well as the principals of the two grade 7-13 schools. There are a total of 127 schools in this population.

A total of 52 interviews were conducted. The sample was drawn to reflect proportionate representation of various school organizations and to reflect an appropriate proportion of each of the primary, junior, and middle (grades 7 and 8) levels. One hundred Peel elementary schools offer primary (kindergarten through grade 3) programs in a K-5, K-6, or K-8 type of school organization. A 20% sample was drawn from within each of these types of school organization. Every fifth school beginning with the fifth school listed alphabetically, by school organization, was selected.

A total of 117 Peel schools offer some or all of the junior level (grades 4 through 6). Junior programs can also be found in K-5, K-6, 6-8 and K-8 school organizations. Every fifth school beginning with the second school listed alphabetically, by school organization, was selected.

Finally, 42 Peel schools offer the elementary school component (grades 7 and 8) of the middle level. These programs are located in K-8, 6-8, 7-8, and 7-13 school organizations. A 20% sample was again drawn from within each of these types of school organization. Every fifth school, beginning with the first school listed alphabetically, by school organization, was selected.

Secondary principals: population and sample

The population included all principals of Peel secondary and vocational schools, as well as the principals of the two grade 7-13 schools. There are a total of 28 schools in this population.

A total of 28 interviews were conducted, one with each principal of a secondary or vocational school within the Peel Board of Education.

Superintendents of schools: population and sample

The population included all 11 superintendents of schools within the Peel Board of Education, as well as the Superintendent of Staff Development and the Superintendent of Special Units.

A total of 11 interviews were conducted, one with each of the superintendents mentioned above.

Resource teachers: population and sample

The population included all resource teachers, past and present, with responsibility for any combination of primary, junior, and middle levels· this excluded resource teachers with E.S.L., G.L.D. or S.L.D. responsibilities.

Thirty resource teachers received questionnaires through the Peel courier system; 28 of these were returned, giving a response rate of 93%.

Instrumentation

Structured interviews were developed for elementary principals, secondary principals, superintendents of schools and resource teachers. The interview questions were based on the findings of the teacher survey portion of the science review. Questions for the elementary principal's interviews were prepared jointly by the Peel Coordinator of Science and the Consultant: Evaluation, while questions for secondary principals, superintendents of schools, and resource teachers were prepared by both the Coordinator of Science and the Science Consultant.

Data collection

The interviews for elementary principals were conducted during May and June, 1987, by either the Consultant: Evaluation, the Chief Research Officer, the Coordinator of Science, or the present or incumbent Science Consultants. The interviews for both the secondary principals and the superintendents of schools were conducted during October and November, 1987 by the Science Consultant. Principals and superintendents were first contacted by telephone to explain the purpose of the interview and to arrange interview times. Interview questions for resource teachers were set up in survey format and distributed to them through the Peel courier system.

Data analysis

Completed interview forms were assigned an I.D. number. A coding system was developed for the two open-ended questions. All data was entered on a computer.

Combined frequencies were generated for the primary and junior levels, and separate frequencies were obtained for the middle level. Due to the small sample size at the secondary level, the secondary and ocational interview findings were combined.

For the resource teacher data, separate frequencies were obtained for the primary, junior, and middle levels.

RESULTS

Elementary principal interviews

Results of the principal interviews for the primary and junior levels are combined for discussion and designated as the early level (K-6); middle level (7-8) frequencies are considered separately. The small sample size at the middle level (n=9) means that these results should be interpreted with caution. Overall, the findings from the interviews do not indicate a high degree of concensus among principals responsible for the early and middle levels.

Early level principals report that the teaching of science is organized in four ways. Science is taught primarily by generalists in their assigned classes (76%), but may also exist as part of a core teacher's program (14%), on a rotary basis (5%), or as a subject that can be traded by teachers (2%). At the middle level, science is taught solely by a "science" teacher through a rotary program (100%).

The data obtained from the teacher survey indicates that approximately two thirds of the elementary teachers surveyed have not studied science beyond high school. Elementary principals do not have a high degree of concensus regarding the impact of teachers' lack of science background on the teaching of science. Over half of the principals responsible for the early level report that this has no impact (60%), while 38% indiate a negative impact, and 2% indicate a positive impact on the teaching of science.

In the middle level, 67% of the principals feel that a lack of science background has a negative impact on the teaching of science, compared to 33% who believe there is no impact. This perceived difference in the impact of a teacher's educational background by early and middle level principals is probably linked to the greater content base at the middle level.

Overall, early level principals detect no discomfort related to the teaching of science among their "science" teachers (71%). Of those who do detect discomfort, 30% feel this is directly related to inadequate educational background; 20% say that inadequate facilities/resources are the cause; and 50% attribute the discomfort to a variety of reasons which include difficulty with the integration concept, lack of motivation, and too much content. Similarly, at the middle level. two thirds of the principals do not detect discomfort by "science" teachers. Of those principals who do report teacher discomfort, 22% link this to inadequate educational background, and 78% offer no explanation.

Principals were asked to rate the quality of the facilities and resources available for science at their school. A majority of the early level principals (74%) rate their facilities as fair or good, 20% as poor or very poor, and 6% as excellent. The rating of available resources is similar: 69% believe the resources are fair or good, 25% report poor or very poor, and 6% say they are excellent. Principals responsible for the middle level rate their facilities as either good (78%) or excellent (22%), and the available resources as mainly fair or good (78%).

The teaching of natural science can be defined to include the three content areas of physics, chemistry, and biology. Principals were asked to approximate the number of hours on average that "science" teachers spend teaching natural science each week. There is no general concensus among early level principals. They report: less than 1 hour (24%); between 1 and 2 hours (4%); 2-3 hours (12%); full range of responses among teachers (7%); and cannot estimate (7%). At the middle level, there is more concensus: 89% of the principals indicate 2-3 hours per week, and 11% indicate 1-2 hours per week. Program Operating Procedure 9 specifies 2 hours at the early level and 2.67 hours of weekly science instruction at the middle level.

Principals at the early level are divided on two issues related to instructional time. When asked whether the amount of time spent per week teaching science was adequate, 51% of early level principals answer affirmately, 39% negatively, and 10% do not respond. When asked if the instructional time in science was proportional, relative to the rest of the curriculum, 48% of these principals say it is, 43% believe it is insufficient, 8% say it is too much time, and 8% do not respond. At the middle level, the majority of principals say that the instructional time is adequate (89%), and 11% do not respond. There is also strong concensus among these principals on the proportionate value placed on science objectives relative to the rest of the curriculum. A majority (78%) believe it is proportional, and 22% believe it is insufficient.

When asked to rank the importance of 14 science objectives, *early level* principals indicate the top three to be social skills, attitudes appropriate to scientific endeavour, and investigative skills and processes. These match exactly the findings reported for the early level teacher survey. When asked to rate their teachers' effectiveness in achieving the top three objectives, on a four point scale (4 being the highest), 87% of these principals give social skills a 3-4 rating, 75% give investigative skills and processes a 3-4 rating, and 84% give attitudes appropriate to scientific endeavour a 2-3 rating. At the middle level, principals replace the social skills objective with "relating scientific explanation to the student's conception of the world" as one of the three most important objectives. Because of the small sample size for middle principals, meaningful effectiveness ratings could not be obtained.

When asked which, if any, of the 14 science objectives were of little or no importance, most principals do not specify any of the objectives. Early level principals who do respond to this question report the following objectives to be of little or no importance to the teaching of science: relating science to career opportunities (32%); understanding the nature and processes of technological or engineering activity (20%); the history and philosophy of science (20%); and the way scientific knowledge is developed (12%). The remaining responses are spread over a number of different objectives. At the middle level, the small sample size does not allow for an accurate interpretation of findings for this question. These principals spread their responses evenly over a variety of objectives. The objective with the highest frequency of response is "the nature and processes of technological or engineering activity" (32%).

A majority of both the principals responsible for the early level (84%) and the middle level (89%), perceive no difference in male or female students' enjoyment of science.

Principals were asked a series of questions related to inservice in science. When asked about the amount of science inservice teachers have had, relative to other subject disciplines, 57% of the early level principals say that there has been less inservice in science, 26% say there has been no inservice; and the remaining 17% are divided between those saying more inservice and those giving no response. At the middle level, 44% of principals say there has been less inservice in science; 22% say there has been more; another 22% say there has been the same amount; and 11% say there has been no inservice offered in science.

When asked about the need for science inservice relative to the need in other curricular areas, 55% of early level principals feel that more is needed; 24% say the same amount is needed; and 19% say that less is required. At the middle level, there is no general concensus: 33% say more; 33% say the same; 22% say less; and 11% have no opinion.

At the regional level, early level principals report that offerings of inservice programs are too infrequent (42%). Another 42% have no opinion; 14% feel these programs are about right; and 3% say they are non-existent. Most middle level principals (89%) have no opinion on this issue (89%); the other 11% say that the frequency of inservice offering is about right. About half of the early level principals (55%) and two thirds of the middle level principals (67%) do not comment on the quality of science inservice offered at the regional level.

Principals were asked whether staff have ever requested or expressed the need for various items related to the teaching of science. Early level principals indicate that staff have requested resources (69%), facilities (38%), inservice in science (19%), and resource teachers (10%). Middle level principals indicate that staff have requested resources in science (78%), inservice in science (67%), and resource teachers (11%).

When principals were asked the extent to which resource staff have provided assistance in the area of science, a majority of early and middle level principals say there has been less than in other subject disciplines (79% and 67%, respectively).

The open ended questions concerning recommendations for the improvement of science education in the region of Peel and in individual schools show few consistent responses. Comments involve the frequency of inservice, budget, amount of science covered in an integrated model, less integration, more integration with other subjects, resource staff, instructional time, curriculum review at the early level, and teacher qualifications at the middle level.

Secondary principal interviews

As was the case for the elementary principal interviews, the results of the secondary principal interviews do not indicate a high degree of concensus.

Secondary principals were given 14 science objectives and asked to select the three objectives which they considered to be most important to a seconary school science program. The following objectives are considered important by secondary school principals: attitudes appropriate to scientific endeavour (57%); investigative skills and processes (43%); content (28%); and social skills (28%). When principals were asked which objectives their teachers believe to be important, there is a higher degree of concensus: content (61%); investigative skills and processes (57%); and attitudes appropriate to scientific endeavour (43%).

Principals rated teacher effectiveness at achieving these science objectives in the classroom on a four point scale (4 being the highest). Secondary principals appear satisfied with science teachers' ability to achieve the four objectives ranked as the most important. All four of these objectives receive a majority rating of 3-4 on the effectiveness scale. The greatest degree of concensus with respect to teacher effectiveness is for investigative skills and processes (100%), and for attitudes appropriate to scientific endeavour (87%). Concensus is less marked for the content (75%) and social skills (66%) objectives.

A majority of principals indicate that all 14 objectives are important at the secondary level. Those principals who report that some of the objectives are of little or no importance specify: awareness of the practice of science in Canada (28%); history and philosophy of science (25%); and nature and processes of technological or engineering activity (25%). The remaining responses are spread over various objectives.

Secondary principals were provided with a list of items which secondary teachers had indicated as obstacles to the achievement of science objectives in the classroom. Principals show the following response pattern in their perception of these obstacles: teacher background and experience (57%); institutional arrangements (50%); curriculum resources (43%); physical facilities and equipment (41%); student abilities and interests (39%); support of school administration (29%); support of Peel resource staff (25%); and community support (11%).

Teachers or principals often request items to improve science programming in the school. When asked to indicate the types of materials which teachers have requested, principals mention improved facilities (82%); improved equipment (63%); more money for resources (59%); a change in institutional arrangements (56%); assistance in program delivery (39%); and more inservice in science (25%).

Secondary principals show no definite response trend with respect to the effectiveness of the inservice program for secondary science teachers in Peel. The comments indicate that inservice in science is seen as non-existent (32%), completely ineffective (14%), fairly ineffective (7%), fairly effective (43%), and very effective (4%). A majority of the principals (81%) report that their science teachers use the offerings in Peel's "Choices" catalogue either moderately or extensively when choosing professional development day programs.

Principals were asked about gender differences with respect to student motivation, ability, and/or achievement. In the area of motivation, secondary principals are about evenly divided, with 52% saying there is a difference and 48% saying there is no difference. Most (93%) of the principals who do indicate a gender difference feel that males are more motivated than females. In the case of both ability and achievement, the majority of principals say they detect no gender differences (82% and 64%, respectively). When principals do note a gender difference, it is always in favour of male students.

The need for strong leadership in curriculum implementation will be essential over the next 3-5 years. As new Ministry guidelines are received, courses of study must be developed and implemented at the school level. Principals were asked who should be responsible for various aspects of the implementation process, such as developing detailed courses of study; preparing lesson plans; identifying resources; identifying teaching strategies; and establishing evaluation methods. The only area where a degree of concensus is seen involves lesson plans. Most principals (89%) believe that teachers should be responsible for their own lesson plans. Minimal concensus is expressed for the remaining items. Principals feel that detailed courses of study should be the responsibility of a committee of teachers representing the Peel region (35%); identifying resources should be the responsibility of the regional coordinator (32%); teaching strategies should be the responsibility of either the department head (32%) or the individual teacher (32%); and evaluation methods should be the responsibility of the school administration (50%).

Although the open ended questions generated discussion and comments, as was the case with the elementary principals, there are no consistent comments to report. Comments involve Ministry documents, budget, inservice, the role of the coordinator and consultant, and teacher attitude.

Superintendent interviews

Superintendents show little concensus on the interview questions. This is probably related to the small sample size (11) and the range of individual experience and areas of expertise of the individual superintendents.

With respect to the relative importance of the 14 science objectives, superintendents indicate three objectives at the early level that are important to the science program: attitudes appropriate to scientific endeavour (90%); relating scientific explanation to the student's conception of the world (60%); and social skills (50%). No concensus is seen with respect to objectives at the middle level. The only objective receiving some concensus at the secondary level is "relating science to career opportunities" (44%). Superintendent interview findings do not indicate any concensus on the effectiveness of schools in achieving science objectives.

Superintendents were asked to indicate which factors were obstacles to the achievement of science objectives in the classroom. All the superintendents agree that teacher background and experience constitute a major obstacle to the achievement of science objectives. Unlike the teacher survey findings, all or most superintendents do not perceive the following factors as obstacles: abilities and interests (100%); community support (100%); physical facilities and equipment (82%); institutional arrangements (64%); support of school administration (64%); or curriculum resources (64%).

Superintendents indicate that improved facilities, more money for resources, and improved equipment are items which schools request most often to improve science programming in the schools.

Although about half of the superintendents (53%) report that the offerings of inservice programs for science teachers are infrequent, they feel that what has been offered is fairly effective (67%). Superintendents believe that more inservice in science is required at both the early (60%) and middle levels (50%).

Superintendents tend to feel that resource teachers are providing less assistance in science than in other subject disciplines (40%).

Superintendents were asked whether they detected any gender differences in students with respect to motivation, ability, or achievement. Superintendents feel that males are more motivated in science (67%). They are equally divided on the issue of achievement in science (50%), and most of them see no gender differences in ability (80%).

In terms of curriculum leadership, most superintendents believe that teachers should be responsible for their own lesson plans (90%); that the identification of resources should be the responsibility of the science coordinator (60%); and that decisions about student evaluation methods should be the responsibility of the school administration (60%).

As was the case with the principal interviews, the open ended questions generated no consistent trends. The following topics are mentioned: inservice, integration, liaison with feeder schools, the role of the coordinator, the need for a higher profile at the elementary level, and the science and society issue.

Resource teacher interviews

In contrast to data gathered from principals and superintendents, the resource teacher findings show a greater degree of concensus on many of the questions. Due to the specific areas of responsibility assigned to resource teachers, various responses were categorized into primary, junior, and middle levels.

Resource teachers at each level tend to believe that teachers' lack of science background impacts negatively on the teaching of science: primary (54%), junior (73%), and middle (67%). At all three levels resource teachers detect the discomfort of teachers who teach science: primary (54%), junior (87%), and middle (67%). There is no real agreement as to the causes of this discomfort. At the primary level, teacher discomfort is linked to both inadequate educational background and the quality of the facilities (63%). At the junior level, the same factors are indicated by 43% of the resource teachers. At the middle level, no pattern is seen.

Resource teachers report that the quality of the facilities in the schools are fair or good (56%), although the resources are rated as being only poor or fair (64%). In the principals' interviews it was noted that resources are one of the most requested items at both the early and middle levels.

When asked about the number of hours teachers spend each week teaching science, resource teachers report less than 1 hour at the primary level and between 1-2 hours at the junior level (41%). At the middle level, resource teachers are split in their response, with 33% indicating 1-2 hours and another 33% indicating 2-3 hours. Resource teachers feel that the time spent teaching science at the primary level is adequate (67%), but 73% do not feel that this is true for the junior level. Resource teachers are undecided about the adequacy of the time devoted to science at the middle level, with 52% not responding. In terms of whether the time devoted to science is proportionate to the rest of the curriculum, resource teachers indicate that the time allotted for science is insufficient.

With regard to gender differences and the enjoyment of science, resource teachers see no difference between male and female students at both the primary level (100%) and the junior level (87%). However, at the middle level about half of the resource teachers do notice a gender difference (55%). Most of the resource teachers who indicate a difference (86%) feel that males are more likely than females to enjoy science.

The resource teacher findings show no strong trends regarding which of the 14 science objectives are important at each level. There is some agreement that social skills, attitudes appropriate to scientific endeavour, and investigative skills and processes are important at the primary level. At the junior level resource teachers tend to stress attitudes appropriate to scientific endeavour, investigative skills and processes, and relating scientific explanation to the student's conception of the world. Resource teachers report similar objectives as important at the middle level, except that "relating scientific explanation to the student's conception of the world" is replaced by "understanding the relevance of science to the needs and interests of both men and women" as an important objective.

A majority of resource teachers report that teachers receive less inservice in science relative to other disciplines (80%); that teachers require more inservice in science (72%); and that regional inservice in science is too infrequent (75%).

Requests for items to improve science programming are often funneled through the resource teacher. Resource teachers indicate that teachers particularly request more resources (83%), more inservice (74%), and improved facilities (74%). It is interesting to note that only 52% of resource teachers report that "science" teachers request more resource teacher time.

Resource teachers are split when it comes to the amount of resource teacher support required in science, relative to other subject disciplines. Approximately half of them (52%) believe it should be the same as in other disciplines, 28% report it should be less, and 20% indicate that there should be more resource time. A majority 88% of resource teachers report that science actually receives less support than other disciplines.

As with data collected from principals and superintendents, the open ended questions elicited no consistent recommendations or comments. Comments concern inservice, integration, budget, liason with secondary schools, and resources.

5.4 REVIEW OF SCIENCE EXAMINATIONS

AND

REVIEW OF WRITTEN CURRICULA

BACKGROUND AND RATIONALE

This portion of the Peel Board of Education Science Review, containing the reviews of science examinations and written curricula in science, is part of a larger two-year kindergarten-through-senior division review of science education in the Board (November, 1986 - June, 1988). In this report, the two reviews will be presented as separate sub-studies.

SUBSTUDY 1.

REVIEW OF SCIENCE EXAMINATIONS:

METHODOLOGY

Population and Sample

The sample of examinations was drawn from the total number of final science examinations set by Peel semestered and non-semestered secondary schools in the following courses of study: SNC 1G, SNC 7A, SPH 3A, SCH 4G, SBI 5A, and SCH 5A. In addition, a sample of items from the Ontario Assessment Instrument Pools for S-17E (Senior Division Chemistry and Senior Division Physics) was also collected for review. Peel semestered schools provide final examinations in January and June; for these schools, a sample of January, 1987 and June, 1987 final examinations was drawn. For non-semestered schools, a sample of June, 1987 final examinations was drawn.

Schools for the sample were chosen at random. Schools were grouped alphabetically into semestered and non-semestered groups, and selections were made rotationally, by course.

Instrumentation

An examination review tally sheet was developed, which provided room to identify for each question on the examination, the science objective being tested, and the level of thinking demanded.

Data Collection

Heads of science in each school selected for the sample were contacted by the Consultant: Evaluation. The intent of the review and assurance of anonymity and confidentially were discussed. A sample of semestered final examinations from the January examination cycle was collected in April, 1987 and analysed in May, 1987. A sample which included both semestered and non-semestered June final examinations was collected and analysed in June, 1987.

A total of 22 examinations were collected from 16 Peel composite secondary schools. Examinations were collected for the following courses of study: SNC 1G, SNC 2A, SPH 3A, SCH 4G, SBI 5A, and SCH 5A. Eleven of the 22 examinations were June examinations, set and administered for non-semestered courses; the other 11 represented semestered final examinations. Table 1 describes the actual composition of exams reviewd.

Data Analysis

Identifying information was removed from all examinations, and they were assigned ID numbers.

Four teachers were selected for the examination review. Three of these were science teachers and represented among them teaching experience and subject specialist qualifications in biology, chemistry, and physics. The science teachers were selected for the task by the Coordinator of Science. In addition, a teacher of English, experienced in both examination review and in the analysis of examination questions according to the level of thinking required, participated in the May full-day review session. The June exam review session was conducted exclusively by the three teachers in science.

The reviewers described each question on each examination in two ways. First, they were given the list of 14 objectives for science education described by the Science Council of Canada; they then determined which objective(s) were being tested by each question. (These 14 objectives were subsequently reclassified into eight Aims of Science Teaching.)

Second, reviewers were provided with a description of the six levels of thinking in Bloom's taxonomy (Taxonomy of Educational Objectives: Cognitive Domain, Bloom, 1956), and were asked to describe the highest level of thinking demanded by each question. When this task was completed, the data was entered on the computer and frequency distributions generated.

Table 1

Summary of Science Examinations Reviewed, by Semestered and Non-Semestered Schools

Course	Semestered n	Non-Semestered n
SNC 1G	2	2
SNC 2A	1	5
SPH 3A	2	1
SCH 4G	2	1
SBI 5A	2	1
SCH 5A	2	1

SUBSTUDY 1.

REVIEW OF SCIENCE EXAMINATIONS: RESULTS

The results obtained from the review of examinations and O.A.I.P. items are reported in Tables 2 and 3. Comparisons of examinations from semestered and non-semestered schools are not presented, since there were no appreciable differences in results from these two types of schools.

Table 2 shows that the results vary only slightly across grade and subject. Science examinations in Peel secondary schools, in all grades and subjects, test scientific knowledge almost exclusively. The remaining responses cluster around objectives dealing with issues and technology. Skill, attitudinal, career, and personal growth objectives are almost never evaluated in the examination setting.

Table 3 shows that the levels of thinking required for these items are almost exclusively recall of knowledge, and comprehension and application of that same knowledge. The physical sciences appear to demand for much more application, in the form of quantitative problem solving, than do general and biological science.

Table 2

Classification of Items from 22 Peel Secondary School Science Examinations and of O.A.I.P. Items into Eight Aims of Science Teaching

Aims of Science Teaching	Intermediate		Senior					
	SCIENCE General (n=229) %	SCIENCE Advanced (n=348) %	CHEMISTRY General (n=132) %	BIOLOGY Advanced (n=184) %	CHEMISTRY Advanced (n=60) %	PHYSICS Advanced (n=211) %	TOTAL (n=1,164) %	O.A.I.P. ITEMS (n=315) %
1. Science content	87	91	90	97	95	90	91	89
2. Scientific skills/ processes	1	1	–	–	–	–	1	–
3. Science and society	4	5	7	2	2	1	4	3
4. Nature of science	1	1	1	1	2	3	1	6
5. Personal growth	–	–	–	–	–	–	–	–
6. Science related attitudes	–	–	–	–	2	–	1	1
7. Applied science/ technology	2	2	2	1	–	5	3	1
8. Career opportunities	–	–	–	–	–	1	–	–

Table 3

Classification of Items from 22 Peel Secondary School Science Examinations and of O.A.I.P. Items into Six Levels of Bloom's Taxonomy

Aims of Science Teaching	Intermediate		Senior					O.A.I.P. ITEMS (n=300) %
	SCIENCE General (n=212) %	SCIENCE Advanced (n=325) %	CHEMISTRY General (n=126) %	BIOLOGY Advanced (n=180) %	CHEMISTRY Advanced (n=57) %	PHYSICS Advanced (n=192) %	TOTAL (n=1,090) %	
1. Knowledge	83	72	45	74	10	31	62	54
2. Comprehension	6	6	18	16	7	9	9	7
3. Application	9	19	32	4	74	57	25	33
4. Analysis	1	1	3	4	5	-	2	1
5. Synthesis	-	1	1	1	-	2	1	3
6. Evaluation	-	-	-	1	4	-	-	1

SUBSTUDY 1.

REVIEW OF SCIENCE EXAMINATIONS:

CONCLUSIONS

- Examinations in Peel secondary schools reflect the emphasis found in both older and intended curricula and in current school courses: an emphasis on the facts of science. These examinations do not reflect the emphases found in the new Ministry science guidelines.

- The Science Council of Canada has expressed the concern that many of the aims of science are not evaluated, and that when this is the case, these aims become meaningless rhetoric. The present sub-study has not reviewed methods other than examinations for evaluating students in science; the analysis of examinations has shown that only a few aims of science education are addressed. If other methods of student evaluation in science prove to be similarly narrow in Peel, the Science Council's concern will apply directly.

SUBSTUDY 2.

REVIEW OF WRITTEN CURRICULA IN SCIENCE: METHODOLOGY

Selection of Reviewing Teams

Three teams of three teacher reviewers were selected: one team to review documents pertinent to science education in the primary and junior divisions, one team to review documents relating to the intermediate division, and one team to review senior division documents. Members of each team were experienced teachers in the respective divisions and were selected by the Coordinator of Science.

Selection of Materials for Review

Written documents were collected from each of the following sources, for each division:

- Ministry of Education (Intended Ministry Curricula)
- Peel Board of Education (Intended Peel Board Curricula)
- Individual Peel Schools (Planned School Curricula)

Specific Ministry and Board documents collected for each division are listed in Appendix A. It should be noted that Ministry guidelines from the past 25 years were analysed along with the draft editions of the 1987 guidelines.

Units from Peel documents were randomly selected, using a process of rotational selection. Individual Peel school documents were randomly requested, based upon proportional samples for each appropriate school organization. For example, primary science is taught in K-5, K-6, and K-8 schools in Peel; 41% of the primary programs are housed in K-5 schools, 44% in K-6 schools, and 15% in K-8 schools. Thirty percent samples of the appropriate proportion of each type school organization were drawn, resulting in samples of 13 K-5 schools, 13 K-6 schools, and 5 K-8 schools.

A similar process was used to determine the sample for grades 4-6 and 7-8. A summary of the samples drawn is presented in Table 4.

In every instance, the Consultant: Evaluation contacted principals by telephone. For the primary division, principals were asked to submit plans for Primary Environmental Studies; in the junior and intermediate divisions, principals were asked to submit plans for science. If principals indicated that specific grade plans were developed by teams of teachers, the school plan for one grade within the division was requested; and if principals indicated that individual teachers developed plans, the plan of the teacher who stood second alphabetically among the teachers of that division, was requested.

It should be noted that only about 25% of the requests for primary division school plans for Primary Environmental Studies resulted in documents which could be reviewed; slightly more than half of the requests for junior division school plans for science resulted in receipt of documents, and all the requests for school plans for science in grades 7 or 8 elicited documents which could be reviewed. For the most part, the difference between the number of plans requested and received reflects principals' reports of the existence or absence of such school plans.

Table 4

Samples of Elementary Documents for Science Education

Division	Schools Contacted n	Submissions n	Documents Reviewed n
Primary	31	11	8*
Junior	19	10	10
Intermediate (grades 7-8)	15	15	15

*Three of the submissions received for the primary division were not reviewed, because only topics without objectives were provided.

The Review Process

Identifying information was removed from all school submissions. Sufficient copies of all documents included within the review were made available to each member of the appropriate review team.

Each three-member review team was provided with tally sheets to record findings. The tally sheets were coded for each division, but otherwise identical for all divisions. Reviewers determined which of the Science Council of Canada's 14 objectives for science education were reflected in each document under review. (These results were later reclassified into eight Aims of Science Teaching.) For each objective, a statement of "Yes" (i.e., definitely stated), "Maybe" (i.e., implied, but not definitely stated as a learning objective), or "No" (i.e., not evidenced at all) was required unanimously from the three-member review team.

All three teams were introduced to their task in the same manner. This involved written instructions, discussion, and trial runs for training purposes.

SUBSTUDY 2.

REVIEW OF WRITTEN CURRICULA IN SCIENCE: RESULTS

The findings of the three teams of reviewers are reported in Tables 5 through 10. These teams worked with documents reclassified by grade into the Ontario Ministry of Education's definition of "divisions". The findings of the combined primary and junior division teams correspond to the Science Council's "Early Years"; the intermediate division to the "Middle Years"; and the senior division to the "Senior Years".

Findings based on the Science Council's 14 objectives for science education (Table 11) were reclassified into eight Aims of Science Teaching (Table 12), used by the Council in reporting their data on curriculum analysis. This reclassification made comparisons with the Canadian context possible. These collapsed versions of the review teams' finding are reported in Tables 13, 14, and 15.

Ontario Curricula versus Other Provinces

The curriculum policy across Canada, as reported by the Science Council, shows a consistent emphasis on science content and scientific skills or processes. Some attention to personal growth is given only in the Early Years, and to science-related attitudes and technology in later years. Attention to personal growth, the nature of science, and careers in science are aims that are largely ignored.

In Ontario, curriculum policy developed from the mid 1970's to the present emphasizes all eight Aims of Science Teaching. Only in documents relating to the senior years do guidelines from the early 1960's show the narrower pattern reported for Canada as a whole. A wider range of objectives emerges in the more recently published policies for all provinces. Across Canada the view of science education at the provincial level is shifting away from a narrow emphasis on scientific knowledge and skills to a broader concept which places science, at all grades, in a social context.

Ontario Curricula by Division

An examination of the findings on Ontario Ministry curricula (Tables 5, 6, and 7) confirms that in more recent years Ministry policy defines science education in a much broader fashion for students of all ages. However, the data also suggests a shift in the importance of various areas, such as the greater attention given to personal growth in earlier years, along with less emphasis on career opportunities in these same years.

Peel "Core" Curricula and Ontario Curricula

Board-level "core" curricula follow the provincial guidelines fairly closely. If Ministry curricula are viewed as the "intended" curricula, then board "core" curricula are an extension of these curricula.

School Curricula and Provincial or Board Curricula

The findings of the primary/junior team (Tables 6 and 7) reveal a series of gaps between the criteria dealt with in school plans and in board "core" curricula. This, combined with the information in Table 4 and the accompanying comment, suggests that little formal planning is done in early years in Peel schools, and what little there is tends to be inconsistent insofar as science is concerned. In fact, the review team comments that they found "... a focus on language arts to the detriment or exclusion of science" in school plans.

At the other extreme, an examination of the findings for the Senior Years (Table 10) reveals school-level plans which, in the words of the review team, "... essentially reflect very well the old Ministry Guidelines", which they characterize as "... content based".

Table 5

Findings of Review Teams, Primary and Junior Divisions: Ontario Ministry of Education, Policy and Support Documents

Science Council Objectives for Science Education	The Formative Years	EPJD Statement of Directions	EPJD Chapt. 6 Environmental Studies	Science in the Primary and Junior Divisions	Shared Discovery (Primary)	Science is Happening Here
1.	X	X	X	X	X	X
2.	X		X	X	X	X
3.			X			
4.	X		X			
5.		X	X	X		X
6.	X	X	X	X	X	X
7.	X	X	X			
8.	X	X	X	X		X
9.	X	X	X	X	X	X
10.		X				X
11.	X	X	X	X	X	X
12.	X		X	X	X	X
13.	X			X		X
14.	X	X	X	X		X

Table 6

Findings of Review Teams, Primary Divisions: Peel Curriculum Documents

Science Council Objectives for Science Education	Board Core: Primary Environmental Studies					Peel Schools, Long Range Plans							
	Introduction	Specific Units											
		A	B	C	D	P12	P11A	P06	P09A	P07	P01	P05	P10A
1.	X	X	X	X	X	X		X	X	X	X		X
2.	X	X		X	X		X	X	X	X			X
3.							X						
5.			X										
6.	X	X							X	X			X
7.													
8.	X	X	X	X									
9.	X	X	X	X	X	X	X	X	X	X	X	X	X
10.			X										
11.	X	X	X										
12.													
13.													X
14.			X										

Table 7

Findings of Review Teams, Junior Division: Peel Curriculum Documents

Science Council Objectives for Science Education	Board Core: Introduction	Peel Junior Science Specific Units			Peel Schools, Long Range Plans									
		A	B	C	J10	J4	J02	J08	J06A	J06B	J07A	J04	J02	J05
1.	X	X	X	X	X				X	X	X			
2.	X									X				
3.										X				
4.	X	X		X					X					
5.														
6.	X								X	X				
7.	X		X											X
8.		X	X							X				
9.	X	X	X	X	X	X			X	X	X			
10.														X
11.				X						X				
12.	X													
13.														
14.	X			X						X				

Table 8

Findings of Review Teams, Intermediate Division

Science Council Objectives for Science Education	Ontario Ministry of Education Guidelines									Peel Board of Education												
	1978		1987							1978									1986 Draft			
	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	J	AA	BB	CC
1.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2.	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X
3.	X	X	X												X		X			X	X	X
4.		X	X		X		X	X	X	X	X	X			X	X	X	X	X	X		
5.		X	X	X				X	X	X		X										
6.	X	X	X	X	X	X	X			X		X			X	X	X		X		X	X
7.	X	X	X		X								X			X						
8.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10.			X																			
11.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
12.	X	X	X	X	X	X	X	X	X		X	X	X		X	X	X		X	X	X	X
13.			X		X			X	X								X				X	X
14.	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X

Table 9

Findings of Review Teams: Long-Range Plans and Courses of Study (Peel Schools)

Science Council Objectives for Science Education	Grade 7-8 Schools									Secondary Schools													
1.	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
2.		X	X	X	X	X		X	X	X		X	X	X	X	X	X		X	X	X	X	X
3.								X															
4.		X	X	X	X	X		X	X	X		X	X	X	X	X	X	X		X	X		X
5.										X							X			X			
6.	X	X	X	X	X	X							X	X	X	X	X	X	X	X	X	X	X
7.															X	X					X		
8.			X					X	X	X	X		X		X	X	X	X	X	X	X		
9.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X
10.																							
11.	X		X			X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		
12.		X	X	*			X	X	X	X	X	X			X	X	X	X		X			
13.																							
14.			X					X	X		X		X		X	X	X		X	X	X		

Table 10

Findings of Review Teams: Senior Division

Science Council of Canada Objectives for Science Education	Ontario Ministry of Education										Peel Board	Peel Schools				
	1960's Guidelines			1987 Guidelines							Curriculum	Courses of Studies				
	A	B	C	D	E	F	G	H	I	J	A	A	B	C	D	E
1.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2.				X	X	X		X		X	X		X	X	X	X
3.				X	X					X	X				X	
4.				X	X	X				X	X	X	X	X	X	X
5.	X	X			X	X	X	X	X	X	X					
6.				X	X	X	X	X	X	X	X			X	X	
7.	X	X	X	X	X	X		X		X	X	X	X		X	
8.	X	X		X	X	X	X	X	X	X	X	X				X
9.	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
10.					X											
11.	X	X		X	X	X		X	X	X	X		X	X	X	X
12.		X		X	X		X	X	X	X	X			X	X	X
13.					X			X		X	X					
14.	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X

Table 11

Classisfication of 14 Science Council of Canada Objectives for Science Education into Eight Aims of Science Teaching

	Objectives for Science Education	Corresponding Aims of Science Teaching*
1.	Understanding scientific facts, concepts, laws, etc.	1
2.	Developing social skills (e.g., cooperation, communication, sense of responsibility)	5
3.	Relating science to career opportunities	8
4.	Developing the skills of reading and understanding science-related materials	5
5.	Understanding the nature and processes of technological or engineering activity	7
6.	Developing attitudes appropriate to scientific endeavour (e.g., curiosity, creativity, skepticism)	6
7.	Understanding the history and philosophy of science	4
8.	Understanding the practical applications of science	7
9.	Developing skills and processes of investigation (e.g., observing, classifying, conducting experiments)	2
10.	Understanding the relevance of science to the needs and interests f both men and women	5
11.	Relating scientific explanation to the student's conception of the world	3
12.	Understanding the way that scientific knowledge is developed	4
13.	Developing an awareness of the practice of science in Canada	3
14.	Understanding the role and significance of science in modern society	3

*See Table 12

Table 12

Sample Interpretations of the Eight Science Council of Canada Aims of Science Teaching

1.	Science Content	"To increase the student's knowledge of basic concepts in life, earth, and physical sciences" (Manitoba)
2.	Scientific Skills/Processes	"To develop facility in using the methods and tools of science" (New Brunswick)
3.	Science and Society	"To promote an understanding of the role that science has in the development of societies and the impact of society upon science" (Alberta)
4.	Nature of Science	"To develop student appreciation of science as a way of learning and communicating about the self, the environment and the universe" (Saskatchewan)
5.	Personal Growth	"To develop as an autonomous and creative individual who will live in a scientific and technological society" (Quebec)
6.	Science-Related Attitudes	"Create an enthusiasm for the method of thinking that uses observed facts as data in a logical method of solving problems" (British Columbia)
7.	Applied Science/Technology	"Students should be exposed to a representative sample of the technological applications of science - communications, transportation, scientific research, medicine architecture, computers, household appliances, energy" (Newfoundland)
8.	Career Opportunities	"To relate science to career opportunities in technology, industry, commerce, business, medicine, engineering, education, research and other areas in which science plays a role" (Ontario)

*Reproduced directly from Table V.1, Volume I, Introduction and Curriculum Analysis, Science Education in Canadian Schools, Background Study 52, Science Council of Canada, 1984.

Table 13

Analysis of Curriculum: Early Years

Aims of Science Teaching	Average, Provinces other than Ontario*	Ontario Ministry Guidelines 1975 Formative Years and EPJD	Ontario Ministry Guidelines 1986/87 Draft Guidelines	Peel Core Curricula 1980 Primary	Peel Core Curricula 1976 Junior	Peel School Plans Primary	Peel School Plans Junior
1. Science Content	X	X	X	X	X	X	(X)
2. Scientific Skills/ Processes	X	X	X	X	X	X	(X)
3. Science and Society		X	X	X	(X)		
4. Nature of Science		X	X		(X)		
5. Personal Growth	X	X	X	X	(X)	X	
6. Science Related Attitudes	X	X	X	X	(X)	X	(X)
7. Applied Science/ Technology		X	X	X	X		
8. Career Opportunities		(X)					

*From Tables V.2 to V.6, Volume I, Introduction and Curriculum Analysis, Science Education in Canadian Schools, Science Council of Canada, April 1984.

X Stated/Frequently Stated
(X) Infrequently Stated/Alluded To

Table 14

Analysis of Curriculum: Middle Years

Aims of Science Teaching	Average, Provinces other than Ontario*	Ontario Ministry Guidelines		Peel Core Curricula		Peel School Plans	
		1978	1987	1978	1987	Gr. 7/8	Gr. 9/10
1. Science Content	X	X	X	X	X	X	X
2. Scientific Skills/ Processes	X	X	X	X	X	X	X
3. Science and Society	X	X	X	X	X	X	X
4. Nature of Science		X	X	X	X	X	X
5. Personal Growth		X	X	X	X	X	X
6. Science Related Attitudes	X	X	X	(X)	X	X	X
7. Applied Science/ Technology		X	X	X	X	(X)	(X)
8. Career Opportunities		X	X		X		

*From Tables V.2 to V.6, Volume I, Introduction and Curriculum Analysis, Science Education in Canadian Schools, Science Council of Canada, April 1984.

X Stated/Frequently Stated
(X) Infrequently Stated/Alluded To

Table 15

Analysis of Curriculum: Senior Years

Aims of Science Teaching	Average, Province other than Ontario*	Ontario Ministry Guidelines 1960's	Ontario Ministry Guidelines 1987	Peel School Plans 1985/86
1. Science Content	X	X	X	X
2. Scientific Skills/ Processes	X	X	X	X
3. Science and Society	X	(X)	X	(X)
4. Nature of Science	X	(X)	X	(X)
5. Personal Growth			X	(X)
6. Science Related Attitudes			X	(X)
7. Applied Science/ Technology	X	X	X	
8. Career Opportunities		X	X	

*From Tables V.2 to V.6, Volume I, Introduction and Curriculum Analysis, Science Education in Canadian Schools, Science Council of Canada, April 1984.

X Stated/Frequently
(X) Infrequently Stated/Alluded to

Summary

. Provincial Ministry curricula have broadened their definition of science for educational purposes, from a very narrow focus on scientific knowledge and process in the 1960's to the inclusion of a personal, social, and technical context in the 1980's.

. Peel board-level "core" curricula, which exist for the early and middle years, closely follow the Ministry policy.

. Peel school plans and planning for science show a marked difference between the Early and Senior Years. In the Early Years, the degree of formal planning is low, and the quality, in terms of adherance to the Science Council's Aims of Science Teaching, is low. There is a distinct tendency for school plans to change science objectives into language arts. In the Senior Years, the planning is much more sophisticated, but tends to adhere strongly to a view of science education as essentially scientific knowledge and process.

SUBSTUDY 2.

REVIEW OF WRITTEN CURRICULA IN SCIENCE: CONCLUSIONS

The analysis of Provincial, Peel Board, and Peel school-level curricula for science confirms that two of the deficiencies in science education across Canada exist in Peel schools as well.

It may be concluded, based upon this analysis of the match between provincial and board intended curricula and the schools' planned curricula, that:

- many elementary students in Peel schools are often denied access to the intended curriculum in science; and

- the present secondary school curriculum for science presents students with a view of science that is narrowly focussed only on knowledge and process.

SUBSTUDY 2.

REVIEW OF WRITTEN CURRICULA IN SCIENCE:

APPENDIX A

SPECIFIC MINISTRY AND BOARD DOCUMENTS REVIEWED

PRIMARY AND JUNIOR DIVISIONS

The Formative Years (1975)	Primary Environmental Studies
Education in the Primary and Junior Division (1975)	Peel Junior Science

INTERMEDIATE DIVISION

Science, Intermediate Division (1978)	Peel Intermediate Science (1982) - Gr. 7 core unit "Living Things" - Gr. 8 core unit "Force & Energy" - Gr. 9/10, Advanced Level, core unit "Continuity" - Gr. 9/10, Advanced Level, core unit "Measurement"

APPENDIX A, continued

Ministry Guidelines	Peel Curricula
Science, Intermediate and Senior Divisions, 1987 (DRAFT, 1986)	
- Part 1., Program & Policy	
- Part 2 & 3, Grade 7 & 8 and General and Advanced Grade 9 and 10 Science:	- Peel (DRAFT '86) Curricula
	- SNC 1A, core unit "Green Plants"
	- SNC 2A, core unit "Applied Chemistry"
- SNC 7, core unit 4	
- SNC 8, core unit 2	- West Central (DRAFT '86) Curricula
- SNC 1G, core unit 3	- SNC 7, core unit "Properties of Matter"
- SNC 1A, core unit 6	
- SNC 2G, core unit 1	- SNC 8, core unit "Investigating Living Things"
- SNC 2A, core unit 2	
	- SNC 1G, core unit "Cells & Cell Systems"
	ALSBO (DRAFT '86) Curriculum
	- SNC 1B, optional unit "Body Functions"
	- SNC 2B, optional unit "Outer Space"

APPENDIX A, continued

Ministry Guidelines	Peel Curricula
SENIOR DIVISION	
Physics, Grade 11, 1966 (S17A)	Peel (DRAFT '86) Curricula
	- SPH 4A, core units 1 & 3
Chemistry, Grade 13, 1967 (RP51)	
Chemistry, Grade 13, 1967 (S17E)	
Biology, Grade 13, 1969	
Science, Intermediate and Senior Divisions, 1987 (DRAFT, 1986)	
- Part 1, Program & Policy	
- Part 7, Applied Chemistry, Grade 11, General Level,	
- core units 3 & 5	
- Part 9, Biology Ontario Academic Course	
- core units 1 & 4	
- Part 10, Chemistry, Ontario Academic Course	
- core units 2 & 6	
- Part 11, Physics, Grade 12, Advanced Level	
- core units 1 & 3	